INFLATION, ECONOMIC GROWTH AND MONETARY POLICY IN INDIA: A MACROECONOMIC ANALYSIS

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DECLARATION

This dissertation was written while I was studying at the Division of Economics, Research School of Pacific and Asian Studies at the Australian National University. Unless otherwise indicated this thesis is my own work.

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ABSTRACT

The on-going debate concerning appropriate macroeconomic policy has contributed to the growing popularity of inflation as the primary target of monetary policy. Issues such as reduced confidence in activist counter cyclical monetary policy, wide spread acceptance of the view that there is no long-run tradeoff between output (or unemployment) and inflation, arguments for the value of precommitment and credibility in monetary policy, and an increasing acceptance of the proposition that low inflation promotes long-run economic growth and efficiency have dominated the debate. However, adopting any particular monetary framework in a given country requires a clear understanding of the economic environment and behavioural relationship between macroeconomic variables.

This thesis is an attempt to examine both the need for inflation control, and the role of monetary policy in controlling inflation for the case of India. The empirical exercise is focused on analyzing the relationship between inflation and economic growth, identifying the inflationary process and examining the effectiveness of the monetary policy regime adopted by the Reserve Bank of India (RBI). It is posited that, in addition to monetary factors, structural factors play an important role in guaranteeing and sustaining the process of inflation. The analysis of the output gap and aggregate demand–supply structure indicates the dominance of supply-side factors in the inflationary process in the Indian economy, which means a monetary policy without adequate accounting of supply side effects may not be able to serve the objective of sustained growth with low inflation.

This study suggests economic growth is adversely affected when the inflation rate exceeds the 5½ percent level and that inflation increases with excessive money growth. A long-term negative effect of inflation on growth and a positive effect of excess growth of money on inflation also mean non-neutrality of money, but, in this situation, the excess money growth is detrimental to long-term economic growth. Therefore, it is pragmatic for monetary policy to concentrate on inflation in preference to anything else.

India has been following a monetary targeting approach since the mid-1980s. However, subsequent to the economic liberalization and financial sector reforms

initiated during the early 1990s, there has been vigorous debate about an appropriate monetary regime. It is observed that the actual money supply has exceeded the announced target in most years. At the same time, the existence of a high fiscal deficit and the provisions of directed credit make it difficult to distinguish between the demand and supply of money. This thesis demonstrates that in the case of India the relationship between broad money and output is not robust. In such a situation, it is inevitable to argue for an alternative policy regime such as the inflation targeting now practiced in several industrialized economies. However, successful inflation targeting requires an efficient inflation forecasting system, complete knowledge of the monetary transmission mechanism, independence and credibility of the central bank and transparency in operations. The analysis of money supply behaviour demonstrates fiscal dominance in the money creation process, which erodes the independence of monetary policy. Therefore, government commitment to fiscal discipline is a precondition to successful adaptation of inflation targeting.

The estimated equation for base money supply indicates historically a passive supply of base money to accommodate inflation, fiscal deficit and output growth in both the short and long run. However, there is evidence of short-run reaction to changes in real exchange rate but that is also accommodated in the long run.

The analysis of the monetary policy reaction function and effectiveness of the policy instruments such as cash reserve ratio (CRR), yield on short term government securities (CGS1) and call money rates (CMR) in controlling inflation and output, indicate that changes in these instruments do not appear to significantly affect the goal variables historically. It is argued that the effectiveness of these instruments may be lost due to passive supply of base money as a parallel action to the stances on these instruments. Particularly, increase in the supply of base money appears to follow an increase in the CRR, with a neutralizing effect. A better approach would be to use a price based instrument such as an interest rate to target inflation.

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GENERAL CONVENTIONS

In order to standardize notations in the text, following conventions are followed as far as possible unless otherwise mentioned.

- Most of the official annual data available on India is for the financial year, which starts on April 1 and ends on March 31. For the sake of convenience, the financial year 1971-72 is written as 1971, for which most months are covered
- Wherever applicable the data is converted to base 1993-94.
- All variables in small case letters (whether italicized or not) are taken in natural logarithms and log always means natural log in this thesis.
- Assigning a negative number equal to the lag length in a bracket following that variable represents lagged variable. Thus, X(-1) represents variable X with one lag.
- A Δ before a variable indicates its first difference. Thus, ΔX = X – X (-1).
- Several variables such as inflation and per capita income growth are represented by the symbols as they are calculated. Therefore, a Δ may be a part of the variable representation as well as a part of re-parameterized variable in a particular specification such as an error correction model. Therefore, representations of basic variables for every estimation are explicitly defined in the relevant sections.
- Some variables have alternative notations in analytical and empirical chapters for the sake of simplicity and reducing clumsiness. However, they are systematically defined everywhere.

Examples:

Variable	Transformation procedure	Notation	Alternative Notation
Price		P	
Log of Price	Log(P)	p	
Inflation	Log(P/(P (-1))	Δp	π
Real gross domestic product (RGDP)		Y	
Population		POP	
Per capita RGDP	Y/POP	YPC	
Per capita real GDP growth	Log(YPC/(YPC (-1))	Δypc	
Call money rate (in fraction)		CMR	
Change in call money rate	CMR – CMR (-1)	ΔCMR	

Chapter 1

Introduction

The growing consensus among policymakers, and particularly central banks, that inflation needs to be controlled, rests on some of the following propositions: (a) Activist monetary policy to reduce unemployment in the short-run might be undesirable because it can lead to higher inflation but not lower unemployment while in the long run price stability promotes a higher level of economic output and more rapid economic growth (Mishkin 1997); (b) Business and households are thought to perform poorly when inflation is high and unpredictable (Barro 1995); (c) Inflation reduces growth by reducing investment and productivity growth (Fischer 1993); (d) Inflation exacerbates tax distortions resulting in substantial net loss to gross domestic product on a perpetual basis (Feldstein 1996); and (e) inflation acts like a consumption tax, promoting a substitution away from work and consumption and towards leisure (Ambler and Cardia 1997).

The intrinsic disadvantages of price volatility are many. Volatile prices may reflect low credibility and commitment of government in responding to inflation shocks and thereby inducing expectations for higher inflation, which in turn makes inflation control more difficult. Inflation causes relative price distortions. For example, if the nominal interest rate is controlled, as is the case in many developing countries, the real interest rate becomes very low and the real exchange rate appreciates, causing a fall in export competitiveness. Fiscal problems are intensified with falling taxes in real terms, which are based on the nominal income of the previous year, while the prices of public utilities are not increased in line with inflation. In addition, given that most future business projections are stated in nominal rather than real terms, stable prices bring more stability in project planning and investment. In this context Goodfriend (1995) considers the underlying mandate of the central bank to aim for a level of inflation so low that 'the expected rate of change of the general level of prices ceases to be a factor in individual and business decision making' (Goodfriend 1995:122).

It is therefore, argued that central banks should emphasize price stability as the single most important objective of monetary policy and eschew consideration of other goals such as growth or employment. The Bank for International Settlements (BIS 1998) observes that the desire to limit the objectives of monetary policy in this way is based on the near-unanimity among economists and policymakers that monetary policy cannot affect the long-term growth of an economy. According to this view, efforts to stimulate growth above its potential rate merely lead to higher inflation: accordingly, monetary policy can at most only moderate short-run fluctuations in output. Moreover, while many central banks may in practice continue to attempt to stabilize output, especially within a medium-term inflation target regime, they find it useful for their public mandate to be restricted to price stability alone, since this reduces their vulnerability to political pressure for expansionary policy.

It is further argued that monetary policy may not be able to achieve goals other than price stability in the case of developing countries due to shallow and volatile financial markets compared with industrialized countries. In industrialized countries, monetary expansion is generally believed to affect output in the short-run, even if such actions merely lead to changes in the price level over longer periods of time. However, in many developing countries, monetary expansion may immediately lead to higher prices either with little or a transitional impact on the level of activity particularly in countries with a history of high inflation and low central bank credibility. Under such circumstances, monetary policy may be required to concentrate exclusively on the goal of price stability.

In the purview of the monetary policy literature (for example Mishkin (1997, 1999), Obsfeld and Rogoff (1995a)) three basic strategies are suggested for achieving price stability: (i) Exchange rate pegging with a large low-inflation country; (ii) monetary targeting; and (iii) inflation targeting. However, the choice of a particular strategy depends upon the commitment of the central bank to other objectives, apart from price stability and the suitability of the economic environment for adopting that particular strategy.[1] Exchange rate pegging with a large country, which has consistently low inflation over a period, exerts direct influence on the inflation rate of the pegging country, which gravitates to the level of inflation in the anchor country, helped by the appropriate expectations. Although, quite successful in controlling inflation, it has been argued that the central bank loses its independence to the pegging country and is forced to contract or expand policy depending on the direction of exchange rate movements alone; shocks of the anchor country transmit to the pegging country leaving it vulnerable to speculative attacks.

In the pure form of quantity theory, inflation is attributed to an excessive rate of growth of monetary aggregates. Specifically, excessive money growth relative to the growth of real output results in rising prices because of more money chasing output. A strong and reliable relationship between the goal variable (inflation or nominal income) and the target monetary aggregate and stability of income velocity of money, which have eluded several countries, are important preconditions for the success of monetary growth targeting in controlling inflation. If there is velocity instability, so that the relationship between the monetary aggregate and the goal variable is weak, monetary aggregate targeting will not work (Mishkin 1999). A weak relationship implies that hitting the target will not produce the desired outcome on the goal variable and the monetary aggregate will not provide an adequate signal about the stance of monetary policy, and fixing inflation expectations.

The question typically raised by critics is why monetary authorities would resort to excessive growth of monetary aggregates? The explanation to this question is intellectual errors in the estimation of money supply requirements and judgments about the nominal rate of interest to be maintained and the amount of credit to be

[1] As of December 31, 1999, countries which have adopted an inflation-targeting framework include Australia, Canada, the Czech Republic, New Zealand, Sweden, the United Kingdom and in some form Israel, Poland, Brazil and Chile (International Financial Statistics 2000 May). In the same document, India is classified with countries like the United States, Germany, France, Belgium, Italy, Spain, Japan, South Africa, Singapore, Switzerland, Norway, and Nigeria among others, which have no explicitly stated nominal anchor but rather monitor various indicators in conducting monetary policy. Most developing countries reportedly follow a monetary framework with an exchange rate anchor, International Monetary Fund-supported regime or other monetary program. A few countries like Colombia, Malawi, and Slovenia are shown to follow a clear-cut monetary aggregate target framework, while several countries classified in the monetary aggregate targeting framework also have other nominal anchors.

created for a stipulated rate of output growth. A related explanation is the discretionary policy and incentive for time inconsistency.

Several countries have recently switched from monetary targeting to inflation targeting in order to achieve price stability. Inflation targeting (IT) involves the central bank's commitment to a pre-announced medium-term numerical target for inflation. The advantage of this strategy lies in its operational features. The central bank knows its objective and people know the objective of the central bank, allowing them to form expectations correctly. Thus, there is transparency in the central bank operations and the bank is accountable to its own commitments. Inflation targeting focuses on domestic considerations and uses all available information to arrive at a forecasted target inflation rate. This means an inflation-forecasting model needs to be developed for the economy as the first step along with imparting independence to central bank operations. However, in practice, the central banks and the government fix an inflation target to be achieved over a specified period.

However, there are also cases of inflation control within a framework having an inclination towards monetary targeting, as in Germany and Switzerland. But Germany is alleged to react asymmetrically to monetary target misses, raising interest rates in response to overshooting money-growth, but choosing not to lower interest rates in response to undershooting. Both have a long-term objective of price stability. The Bundesbank and Swiss National Bank actively engage in communicating the strategy of monetary policy to the public, thereby enhancing the transparency of monetary policy and the accountability of the central bank (Mishkin 1999). Mishkin considers them "hybrid" inflation targeters as their practices are closer to inflation targeting than Friedman-like monetary targeting.

Although, price stability is emphasized as the major goal of central banks, in practice central banks in developing countries, being typically the dominant force in the financial market of the country, shoulder other responsibilities, including structural development of the financial system, adequate credit creation for the private and public sectors, and external balance. Several are heavily dependent on developmental aid from international organizations like the International Monetary Fund (IMF) and the World Bank, which impose their own agenda and stabilization policies. With an objective of inflationary control, many developing countries have relied on the exchange rate anchor notwithstanding its constraints on monetary independence.

In the Indian debate, inflation is not considered entirely a monetary phenomenon.[2] It is believed that inflationary pressure builds up from both the supply as well as the demand side. Supply-side shortfalls or shocks in the prices of primary products are also reflected in the manufacturing sector. To manage supply-side inflation government intervention is invoked in the form of physical controls and trade policy measures. Demand-side inflation is dealt with through appropriate macroeconomic policies involving control of the money supply and restricting monetisation of the fiscal deficit.

This thesis examines the importance of inflation control, the role of monetary policy in controlling inflation, and the possibility of India adopting inflation targeting. The remainder of this introduction is organized as follows: A brief account of monetary policy in India is given in section 1.1. Constraints on monetary policy in India are discussed in section 1.2. The current debate in India and the key questions are discussed in section 1.3, and the organization of the thesis is presented in section 1.4.

1.1 MONETARY POLICY IN INDIA: AN OVERVIEW

1.1.1 Objectives

Monetary policy in India is assigned the dual objective of: (1) maintaining a reasonable degree of price stability in the economy through the regulation of monetary growth and (2) ensuring adequate expansion of credit to assist economic growth (Rangarajan[3] 1998:70). However, the relative emphasis placed on these two objectives has changed from time to time. Apart from these two main goals, more recently, the Reserve Bank of India (RBI) has also been engaged in maintaining orderly conditions in the foreign exchange market to curb destabilizing and self-fulfilling speculative activities (Reddy[4] 1999d).

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[2] See, for example, commentary on price and distribution in various issues of Economic Survey (particularly issues from 1993-94 to 2000-2001) and in a survey article by Bhattacharya and Lodh (1990). Economic Survey is the official document of the Ministry of Finance issued before the presentation of the annual budget of the Government of India.

[3] Dr Rangarajan is a former Governor of the Reserve Bank of India.

[4] Dr Y. V. Reddy is Deputy Governor of the Reserve Bank of India.

1.1.2 Intermediate Targets

Monetary policy in India since the mid-1980s has primarily been governed by the Chakravarty Committee Report (RBI 1985), which recommended that India pursue a monetary targeting approach. The supply of the broad money aggregate (M3)[5], instead of the interest rate was chosen to be the intermediate target under the contention that the demand function for money in India has remained fairly stable with respect to a 'select set of variables' (Rangarajan 1998).

The report of the Chakravarty Committee (RBI 1985), while recommending monetary targeting for India, qualified it by arguing that the 'mechanical application of constant money supply growth rule has no place' due to the significant structural changes required to facilitate the growth process. It is in this context that Rangarajan (1998:64) considered the Indian monetary regime a flexible monetary targeting regime. Another important aspect of the Chakravarty Committee Report was a presumed 4 percent target for inflation. However, it appears that over time the monetary authorities in India underplayed the importance of low inflation. Average annual inflation in India as measured by the wholesale price index (WPI) was 8.19 percent during 1971-98 and 8.22 percent during 1991-98. On the other hand, trade weighted annual inflation in India's five major trading partner countries[6] during the corresponding periods was 5.24 percent and 2.35 percent, respectively. The approximate position of monetary targeting with respect to targets and the actual values of broad money growth, the inflation rate and real output growth rate is presented in Table 1.1.

Clearly, the RBI has not been following an absolutely fixed growth rate of money supply. Significant variations ranging between 11 to 19 percent can be observed in targets across periods. The money supply growth target in India is derived from a long-run money demand function, where income is represented by the exogenously given 'anticipated' growth rate and 'tolerable' rate of inflation (Vasudevan[7] 1999). The desired level of reserve money is aligned with the targeted level of broad money expansion. However, the money multiplier is not used for this back tracking. Instead, backward tracking of reserve money has to be consistent with the likely fiscal and external payments position in view of the fact that the main sources of expansion of

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[5] See Chapter 6 for details on components of monetary aggregates

[6] The United States, Japan, United Kingdom, Germany and France.

[7] Dr A. Vasudevan is Executive Director in RBI

reserve money are the RBI credit to government and net foreign exchange assets (Reddy 1999d). Thus, the money multiplier must be manipulated by using instruments of quantitative controls. Therefore, it is not surprising that the money multiplier in India has a unit root. In such circumstances, reserve money also becomes an intermediate target. Reddy (1999d) prefers to call it an underlying operating target.

Table 1.1 Target and actual rates of broad money (M3) growth, real output growth and inflation in India (1983-98)

Year	M3 growth (%)		RGDPF* growth (%)		WPI-Inflation (%)	
	Target	Actual	Target /objective	Actual	Target /objective	Actual
1983-84	< 16.2	18.2	-	8.3	-	7.6
1984-85	<18.2**	19.0	-	3.8	Curb Inflation	6.0
1985-86	<19.0***	16.0	~3.8	4.1	Avoid resurgence	4.8
1986-87	<17.5	18.6	> 4.1	4.8	Continue check	5.1
1987-88	<18.6	16.0	5.0	4.3	Avoid re-emergence	10.7
1988-89	<16.9	17.8	-	10.6	-	5.7
1989-90	<17.1	19.4	4-5	6.9	-	9.1
1990-91	<15.4	15.1	~5.0	5.4	-	12.1
1991-92 (April)	<14.0#	19.3	4.0	0.8	Max 7.0	13.6
1991-92 (October)	<13.0		3.0		Max 9.0	
1992-93	<11.0##	15.7	-	5.3	8.0	7.0
1993-94	~12.0	18.4	5.0	6.2	Further Moderation	10.8
1994-95 (April)	14.0-15.0	22.3	5.0	5.3	~ 6.8	10.4
1994-95 (October)	16.0 (Max)		5.5			
1995-96	15.5 (Max)	13.7	5.5	7.2	~ 8.0	5.0
1996-97	15.5-16.0	16.2	6.0	7.5	6.0	6.9
1997-98	15.0-15.5	17.6	6.5-7.0	5.1	5.0-6.0	5.3
1998-99	15.5-16.0	18.4	6.0-7.0	6.8	~5.0	4.8

Notes: * Real Gross Domestic product at factor cost; ** Growth of liquidity and primary money creation; *** Liquidity growth; # M3 Target was made consistent with the containment of gross fiscal deficit to 6.5 percent of GDP in 1991-92; ## M3 Target was made consistent with the containment of gross fiscal deficit to 5.0 percent of GDP in 1992-93.

Sources: Based on Mohanty and Mitra (1999). The cited sources of their data are Reserve bank of India Annual Report, various issues; Circulars issued by Credit Planning Cell/Monetary Policy Department, Reserve Bank of India. Table is updated for the period 1998-99 using data from the RBI annual report and Economic Survey (1999-2000). Some of the values for the period before 1990-91 are quantified from implied statements like 'less than previous year' or 'less than average of last four years', given in Mohanty and Mitra (1999).

With freeing of commercial banks' lending rates in 1997, the overnight call money rate has also been considered a supplementary operating target, proxying for the short-term interest rate. It appears the emphasis on the broad money growth target is bound to decline as the central bank has now begun to rely on an array of indicators. Information is being assembled on currency, credit extended, fiscal position, trade, capital flow, interest rates, inflation rate, exchange rate, refinancing and transactions in foreign exchange. The objective of the central bank in building such an information base to formulate a clear-cut interest rate channel of transmission was emphasized in its 1997-98 annual report (RBI 1998).

1.1.3 Policy Instruments and Operating Procedures

Since 1960, the Reserve Bank of India (RBI) has had a range of monetary policy instruments at its disposal, including direct (quantity) and indirect (price) instruments with their emphasis changing from time to time (Joshi and Little 1994). The most powerful direct instruments include the cash reserve ratio (CRR)[8], Statutory liquidity ratio (SLR)[9], quantitative controls on Reserve Bank lending to banks and the commercial sector ("refinance"), and quantitative credit controls. The indirect instruments operate through the administrative setting of various interest rates. While the CRR affects reserve money directly by immobilizing banks' cash holdings, the SLR affects reserve money indirectly by reducing the monetisation of fiscal deficits. The government finds a 'captive' market for its securities in the form of SLR, which leads to diversion of a large amount of bank resources to the government. SLR rose to 37.4 percent in 1992. It may be noted that most commercial banks in India are in the public sector. Therefore, government can easily influence them.

Following the recommendations of the Committee on Financial Systems[10] (CFS), the financial sector reforms[11] (FSR) were started in 1992. Since then, the central

[8] Since 1962, the RBI has been empowered to vary the CRR between 3 and 15 percent of total demand and time liability. CRR in excess of 3 percent is currently remunerated at 4 percent per annum (Reddy 1999b).

[9] Over and above the CRR banks are required to maintain a minimum amount of liquid assets in cash, gold, and government securities amounting to a specified share of their demand and time liabilities.

[10] The report of the Committee on Financial System (CFS) was submitted in 1991 and Mr. M. Narasimham was the chairman of the committee. Therefore, CFS is also known as the Narsimham Committee report (1991). Subsequent to this report, the government appointed another committee, the Committee on Banking Sector Reforms (CBSR), again with Mr. Narasimham as committee chair with an objective to review progress made in reform of the banking sector and to chart the actions needed to strengthen the foundation of the banking system. The CBSR was submitted in April 1998. For a summary see RBI (1998b).

[11] The reforms include inter-alia the free floating of the exchange rate, decontrol of interest rates, development of securities markets, greater reliance on open market operations, auctions of government securities, phased decontrol of the capital account, and putting in place the prudential norms and mechanism for supervision of banking sector in line with international standards and practices. For a comprehensive detail with analysis see Reddy (1999b). Also see IMF (1998), Ahluwalia (1999), Reddy (1999), Reddy (1999a), and Reddy (1999c).

bank has been endeavoring to move away from quantitative controls towards an interest rate channel for monetary transmission. The central bank tends to rely more on open market operations (OMO) in dated Treasury Bills, repo operations, auction and private placement of Government securities in conjunction with the Bank Rate for maintaining medium and long-term interest rates and management of situations arising out of heavy borrowings by the government.

The structure of administered interest rates has almost been dismantled since 1997. In the case of deposits, only the interest rate on savings bank deposits remains under RBI control. At present this is prescribed at 4.5 percent (May 2001). Among the lending rates the RBI now directly controls only the interest rate charged for export credit, which accounts for about 10 percent of commercial advances[12] and indirectly controls the interest rate on small loans of up to rupee 200,000, which accounts for about 25 percent of total advances. Commercial banks are not allowed to exceed their Prime Lending Rate (PLR)[13] in the case of loans up to rupee 200,000.

Thus among the more conventional instruments, CRR, SLR and sectoral refinance (export) are still in the armory of the RBI. Nevertheless, realizing that the reserve requirements amount to a tax on intermediation, which reduces the profitability of banks, these ratios are systematically being reduced. The statutory minimum for SLR has been brought down to 25 percent. However, commercial banks hold SLR more than the statutory prescription (Reddy 1999b). The cause of this phenomenon can be attributed to excess liquidity in the system where there is inadequate demand for bank credit (Rakshit 1994).

To reduce the role of quantity variables the RBI has taken initiatives to activate the rate variables through development of the government securities market as part of its policy reform in 1992. Measures taken to improve securitization of the money market, including permission for foreign institutional investors to invest in Treasury Bills (TB), are helping deepen the securities market (RBI 1999).

The market based exchange rate system[14] with occasional intervention from the RBI was introduced in March 1993. Some initiatives have also been taken towards

[12] For export credit the RBI provides refinancing at concessional rates that mitigate the burden of this particular control on the banking system.

[13] Each commercial bank is statutorarily required to declare their Prime Lending Rate in advance.

[14] According to the International Financial Statistics (IFS) the Indian Rupee is market determined since March 1, 1993 and is classified as an independently floating exchange rate.

Capital Account Convertibility (IMF 1998) in line with the recommendations of the Committee on Capital Account Convertibility (RBI 1997). As an initial step, import of gold[15] by banks fulfilling certain criteria and by individuals returning to India was relaxed. Subsequently, restrictions on overseas borrowing and investment activities of banks and corporate bodies have also been relaxed. Up to 100 per cent foreign direct investment (FDI) is now permitted in several sectors. In the insurance sector, foreign equity is allowed up to 26 per cent. Norms for external commercial borrowing (ECB) have been substantially liberalized (see (GOI 1999; GOI 1999a; GOI 2000; GOI 2001)). However, the pace of capital account convertibility was dampened following the South East Asian financial crisis with some favorable results of avoiding contagion (Joshi 2001).

With these reforms, new dimensions have been added to the problem of liquidity management for the RBI. Currently, short-term liquidity management is done in the form of an Interim Liquidity Adjustment Facility (ILAF); liquidity is injected by the RBI through the Collateralized Lending Facility (CLF) to banks, export credit refinance to banks, and liquidity support to primary dealers (PDs) of government securities. All these facilities are available subject to (formula based) quantitative limits for a specified duration and at bank rates. Absorption of liquidity takes place through fixed rate repos (rates being announced on a day to day basis) and OMOs in government dated securities by the RBI. However, it is important to note that these operations are in the given framework of the CRR that directly affects liquidity and the Bank Rate (Reddy 1999d).

1.2 CONSTRAINTS ON MONETARY POLICY IN INDIA

The efficiency of a central bank is contingent upon the economic environment in which it works. Two aspects need to be clarified here. The first relates to central bank independence. The second relates to the financial depth, fiscal compulsions, overall economic structure, and the political mandate of the country, which determine the possibilities for monetary policy and the effectiveness of policy stances. The literature related to central bank independence is vast including literature on the rule versus discretion debate and political independence (see for example Cukierman (1992), McCallum (1993), McCallum (1995), Mas (1995),

[15] India being the largest market of gold, this was considered a significant step in relaxing capital control.

Walsh (1995), Blinder (1999), among others). In simple terms, 'central bank independence means two things: first, that the central bank has freedom to decide how to pursue its goals and, second, that its decisions are very hard for any other branch of government to reverse' (Blinder 1999). Fischer (1994) argued that the central bank should have instrument independence but not goal independence.

There is less controversy regarding who should set the goals, particularly, in a democratic system. Once the long-term mandates are set, the means of achievement can be left to the central bank. However, the debate concerning rule versus optimal policy decision has limited applicability in the context of developing countries, which face an environment that differs radically from that faced by central banks in advanced economies (Masson, et al. 1997). The choice of most senior civil servants to represent governments on the board of directors of central bank in the developing countries is common (Fry, et al. 1996:28), which reflects the amount of influence governments in these countries exert on the central bank to look after its fiscal interest. India is no exception and runs a large fiscal deficit. Therefore, it is important to focus upon the economic environment and the constraints under which the RBI operates.

1.2.1 Financial Deepening

As mentioned earlier, the RBI is struggling to move from a more controlling mode to indirect market-based techniques to implement monetary policy. This requires commensurate financial development in the country, which can be assessed by looking at the financial ratios.[16] Cole and Patrick (1986) have used broad money to GDP ratio to measure financial deepening in developing countries. The banking sector plays a dominant role in financial intermediation in India, which is supplemented by several other types of financial institutions including insurance companies and mutual funds. Therefore, bank density in terms of thousands of people per branch of commercial banks indicates institutional expansion for

[16] In the literature, (see for example Goldsmith (1969)) several measures are suggested to measure financial deepening. These include: (1) the Finance Ratio, which is the ratio of total financial claims issued during the year to national income; (2) the Financial Inter-Relation Ratio, which is the ratio of the total volume of financial assets at any point of time to the stock of physical assets at that time; (3) the New Issue Ratio, which is the ratio of primary issue to net physical capital formation, primary being defined as the financial claims issued by the non-financial sector; (4) the Intermediation ratio, which is the ratio of the volume of financial instruments issued by financial institutions to the volume of primary issues by non-financial units.

intermediation. Table 1.2 compares some of these variables in India with the United States, Brazil, South Korea and Singapore. While United State represents the most developed market economy, Brazil, South Korea and Singapore belong to the group of fast growing developing economies with better economic condition than India.

Table 1.2 Some measures of financial deepening in India vis-à-vis Brazil, Korea Rep., Singapore and USA.

Country	Period	Broad Money as percentage of GDP	Broad Money to Reserve Money Ratio	Deposit to Reserve Money Ratio	Commercial bank density (thousand people per branch)
India	1971-75	25.99	2.54	1.66	39
	1976-80	34.70	2.88	2.10	24
	1981-85	39.20	3.04	2.35	17
	1986-90	45.60	3.06	2.44	14
	1991-95	49.20	3.18	2.55	14
	1996-98	52.20	3.64	2.97	15
India*	1996-98	47.80	3.46	2.33	
Brazil*	1996-98	29.40	4.30	3.46	
Korea Rep.*	1996-98	48.34	9.49	7.88	
Singapore*	1996-98	95.73	7.42	5.90	
USA*	1996-98	58.60	9.50	7.01	

Note: Data marked * are comparable as these are calculated using consistent definition of series and the data from IFS. The other values given for India are calculated using the sources and definitions of data used for this study and given in Appendix AA.

Data Sources: (1) for * countries: IFS line 64x for CPI inflation, line 99b/99bc for GDP, line 14 for monetary reserve, line 35 for deposit as quasi money, line 34 plus line 35 for the broad money M2. (2) For the India data (without *): World development indicators CDROM2000 for GDP, RBI (1999, 2000) for broad money M3 and reserve money M0 (defined in Appendix AA). Deposit is demand deposit plus time deposit. Based on these data the percentages and the ratios are calculated by the author.

The ratio of broad money to GDP in India has risen substantially from a level of about 26 per cent during 1971-75 to 52 percent during 1996-98 and is comparable with other countries. However, central bank liabilities in India in the form of reserve money are much higher than the other four countries in the comparison. The broad money to reserve money ratio is barely over one third that of the United States and Korea. The same situation holds for the deposit to reserves ratio. High reserve (of the order of rupees 26 trillion in 1998-99 and an average of rupees 6.8 trillion during 1970-99), in India enables the government to borrow from the RBI at no cost either directly or through transfers of the RBI surplus. However, it limits advantage of the stances taken on instruments and may be more inflationary. Nevertheless, the encouraging aspect is higher growth in these ratios during the post liberalization period, which is the direct outcome of reduction in the CRR. It is imperative for the RBI to enhance its securitization process and the use of OMO, and reduce the CRR even further. Bank density stagnated during the 1990s and the number of banks per thousand people even fell as an after-effect of the financial sector liberalization in slowing bank branching in rural areas.

1.2.2 Quasi Fiscal Activity and Fiscal Constraints

It is not uncommon for governments of many developing countries to assign various quasi-fiscal activities to their central banks like collecting seigniorage[17], imposing financial restrictions and implementing selective credit policies (Fry 1993). These activities may erode the functional independence of central banks. The practice of revenue collection from seigniorage and inflation tax is well documented in Friedman (1971), Phelps (1973), and Fischer (1982). By expanding the currency issue faster, the central bank can raise the inflation and inflation tax rate, which in turn raises the opportunity cost of holding currency.

In the simplest model, the central bank can be assumed to hold assets equivalent to reserve money earning the market interest rate and liabilities of reserve money paying no interest, thus collecting profits. The inflation tax and seigniorage revenue can be calculated following the method used in Easterley, et al. (1995), Fry, et al. (1996) and Masson, et al. (1997). Numerical values calculated for India and four other countries are presented in Table 1.3 along with the combined fiscal deficit and monetised deficit of Central and State Government.

From Table 1.3 it may be noted that the record of fiscal deficits in India does not compare favourably to the reference countries of United States, Brazil, Korea and Singapore. However, there has been some improvement during the 1990s. Seigniorage is also consistently high. With a high fiscal deficit in the order of over 9 percent, comparatively high seigniorage and monetisation become compulsive for the monetary authorities. However, a high inflation tax and a tendency to collect seigniorage at a higher level can feed further inflation and ultimately lead to a crisis situation. 'Allowing monetary policy to accommodate fiscal pressures not only leaves the inflation rate determined by the fiscal authority, but - because of the possibility of multiple equilibria - also increases the likelihood that the economy will find itself operating at an inflation rate higher than it need be' (Bruno and Fischer 1990). Therefore, reducing the fiscal deficit by reducing expenditure and increasing

[17] Central banks in developed countries also collect seigniorage. However, in the case of developed countries it may not be an intended source of public finance.

the revenue base must be the government focus in order to allow monetary policy to do its job.

Table 1.3 Inflation tax, seigniorage and fiscal deficit in India, Brazil, Korea Rep., Singapore and USA.

Country	Period	Annual Inflation	Inflation tax	Seigniorage	Fiscal deficit	Monetised Deficit
India	1971-75	10.96	9.34	1.04	5.48	1.00
	1976-80	7.85	6.91	0.47	6.98	1.51
	1981-85	6.40	5.98	1.09	9.04	1.23
	1986-90	7.53	6.99	1.15	10.99	2.25
	1991-95	9.64	8.76	1.46	9.38	0.66
	1996-98	5.85	5.53	1.27	9.06	0.70
India*	1996-98	9.80	8.88	1.22	5.32	
Brazil*	1996-98	8.63	7.73	0.52	-	
Korea Rep.*	1996-98	5.60	5.29	0.27	1.85	
Singapore*	1996-98	1.03	1.01	0.14	-13.52	
USA*	1996-98	2.27	2.21	0.14	0.28	

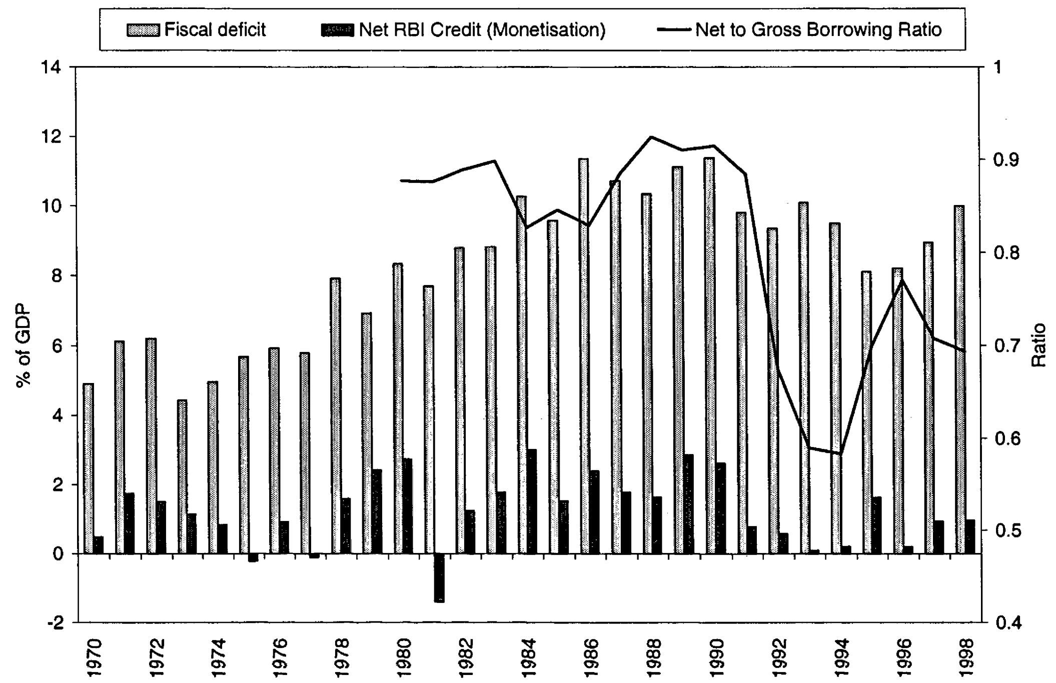
Notes: Data marked * are comparable as these are calculated using consistent definition of series and data from IFS. The other values given for India are calculated using the sources and definitions of data used for this study and given in Appendix AA. The inflation for India* is CPI inflation, while for India it is WPI inflation, which is the preferred price index in this study (see chapter 4 for more details). The inflation tax is calculated using the definition $100*\pi/(100+\pi)$, where π is period inflation in percentage. Then seigniorage is calculated as the inflation tax multiplied by the stock of monetary reserve money divided by nominal GDP. Fiscal deficit and monetised deficit are expressed as percentages of the GDP. Since 1997, the RBI has paid 4 percent interest on the deposits of commercial banks with the RBI, which forms part of reserve money. No adjustment is made for this.

Data Sources: (1) for * countries: IFS line 64x for CPI inflation, line 99b/99bc for GDP, line 80 for Central Government fiscal deficit (+ deficit & - surplus), line 14 for monetary reserve, line 34 plus line 35 for the broad money M2. (2) For the India data (without *): Economic survey various issues for WPI and combined deficit of both Central and State Governments, World development indicators CDROM2000 for GDP, RBI (2000) for Net RBI Credit representing monetised deficit. Based on these data the percentages and the ratios are calculated by the author.

It is encouraging to note that during the post reform period the extent of the monetization of the fiscal deficit (gap between the total outlay of Center and State Governments and total current revenue) expressed as a percentage of gross domestic product (at current prices) reduced from an average of 2.25 percent for the period 1986-90 to 0.69 percent for 1991-98. Full period details are plotted in Figure 1.1.

The practice of automatic monetization of the fiscal deficit was completely abolished in April 1997. However, this has led to sharp increases in government borrowing. Figure 1.1 presents the ratio of net to gross borrowing of the Central and State Governments for the 1980s and 1990s, which dropped from 0.89 in 1991-92 to 0.69 in 1998-99. This is a stark reflection of the erosion of the government's borrowing potential. The RBI policy statement, 1999-2000, (RBI 1999b) observed that government borrowing was reaching its limits (the banking sector held government securities of around 33 percent of its net demand and time liabilities as against the minimum requirement of 25 percent).

Figure 1.1 Fiscal deficits, monetization and net to gross borrowing of Government (1970-98)



Notes: Fiscal deficit and Monetisation are shown on left scale, while Net to Gross ratio is shown on the right scale

Data Sources: World Development Indicators CDROM 2000 for GDP; Economic Survey various issues for Fiscal deficit; RBI (2000) for Net RBI Credit, and Gross and Net borrowing of Central and State Governments. Based on these data the percentages and the ratios are calculated by the author.

While non-accommodating monetary policy is desirable in the presence of fiscal rigidities it is also important to ensure the country does not fall in to a high-interest rate trap (Rao and Rao 1998). Therefore, limited monetisation can still be helpful in order to control the rise in interest rates in the face of heavy Government borrowing. The central bank cannot afford to close its eyes to this problem. Under these circumstances, it can be argued that the independence of the central bank is de-facto compromised. In this light, in order to understand the money supply behaviour of the

RBI it may be reasonable to include fiscal deficit as an alternative or additional scale variable in addition to output.

1.2.3 Policy of Directed Credit: The Structural Mandate

There is an explicit role in India for the banking sector to support priority sectors of the economy. Commercial banks are required to direct about 40 percent of their advances to such priority sectors, which consist of agriculture, small-scale industries, small-scale transport operators, artisans, etc. Within this aggregate ceiling, there are sub-ceilings for agriculture and for loans to poverty-related target groups (Ahluwalia[18] 1999). The interesting part of this control is that most borrowers in these groups are also small borrowers, less than Rs 200,000, in which case there is the upper limit to the interest rate determined by the prime-lending rate (PLR) of the respective banks. The conclusion that can be drawn here is that liberalization of interest rates has only been partial.

There are many arguments both in favour (Stiglitz and Weiss (1981), Stiglitz (1994)), and against directed credit (Fry (1997), Arestis and Demetriades (1997)). Projecting the nature of this self-defeating scheme is the most important criticism. Given that most banks fall under the public sector, political influence could be the single most damaging aspect, leaving aside general market failure.

The Committee on Banking Sector Reforms (CBSR) has observed that Directed Credit has a proportionately higher share in the non-performing assets (NPA) portfolio of the banks and has been one of the factors involved in eroding the quality of bank assets. While recognizing the importance of directed credit for agriculture and small business sectors, the CBSR recommended that the limit of directed credit be reduced to 10 percent and bank branch managers be fully responsible for identifying beneficiaries in order to improve the quality of banks' assets. The CBSR also recommended eliminating the subsidy element in credit for priority sectors and deregulating loans under Rs 200,000 (as has been done in the case of Regional Rural Banks and co-operative credit institutions). The CBSR believes it is the timely and adequate availability of credit rather than its cost, which is material for the intended beneficiaries. The government has not yet (May 2001) accepted these recommendations.

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[18] Dr M.S. Ahluwalia is former Secretary, Finance, to the Government of India.

There are important implications for these controls of monetary policy. First, in order to meet the targets of directed credit, commercial banks end up accumulating non-performing loans (NPL) and pushing excess money into the system that can cause inflation. Second, due to extraneous influences directed credit may not entirely go to productive purposes. Thirdly, the role of the interest rate as the opportunity cost of money is substantially weakened due to market failure in this sector. It is also possible that several banks facing a severe NPL burden due to directed-credit will prefer to reduce their overall credit in order to reduce the negative effects. There is no provision for trading between banks to transfer directed credit from one bank to another with more expertise in handling directed credit. Ahluwalia (1999) thinks that if such trading could be introduced it would reduce the total cost of directed credit.

1.2.4 Government Interventions in the Commodity Market

More than a quarter of the wholesale price index weight items come under direct or indirect intervention by Central and State Governments. In particular, prices of fuel and agricultural items are moderated. During the crop seasons, the Governments declare support prices and get involved in buying produce at a higher price than would have been possible otherwise. This policy has merits as well as demerits as it helps to protect farmers who are vulnerable to exploitation by wholesale dealers in agricultural produce. Poor infrastructure and lack of good storage facilities add to farmers' vulnerability. It also reduces wide-ranging fluctuations in crop prices across seasons. However, the demerits lie in the fact that the prices declared by Government have political overtones and are capable of creating distortion in forecasting inflation and formulating monetary policy. This distortion may be greater in the case of intervention in imported items like fuel, because international fuel prices cannot be directly used to model inflation.

1.3 THE CURRENT DEBATE ON MONETARY POLICY IN INDIA AND THE KEY QUESTIONS

From the foregoing discussion, it is clear the Indian economy is passing through a stage where monetary policy needs to be re-examined and there is a vigorous debate on the appropriate monetary regime and policy objectives. Reddy (1999d), the Deputy Governor of the RBI, is concerned about several 'dilemmas' facing the central bank, including problems arising from a trade-off between growth and inflation in the short-run and management of public debt. He also recognizes that in a dynamic setting with continuous evolution in technology and financial systems, the stability of demand for money function may be undermined.

Vasudevan (1999) observes that the actual money supply (see Table 1.1) has exceeded the announced targets in most years, raising doubts about the stability of the broad money demand function or the correctness of adapting the operating procedure of targeting bank reserves. In a similar vein, Mohanty and Mitra (1999) observe that increasing market orientation of the financial structure and international capital flows has created the need to consider whether a monetary targeting approach could ensure internal and external stability. They argue that even if the money demand function shows some kind of stability, it cannot be guaranteed that targeting broad money will remain optimal in a changing environment of external and financial sector reforms.

It was inevitable that focus would shift towards an inflation-targeting framework as in many industrialized economies. Kannan (1999) reviewed the idea of inflation targeting in the Indian context and argues for completing the financial sector reforms before implementing inflation targeting. Kannan's concerns about the development of a suitable inflation model for India and investigation into the effectiveness of the interest rate in conducting monetary policy are timely. However, making price stability an overriding objective of monetary policy itself could be a first step in the right direction of inflation targeting. Reddy (1999e) argues that the 'short-term deviation in the relationship among money, output and prices ought not to be construed as a breakdown of the inherent linkages. Yet, there are a number of recent developments warranting intense research and analysis of the evolving relationship between growth in money supply and inflation'.

McKibbin and Singh (1999) conducted simulation studies using McKibbin Sachs Global (MSG) model for three alternative policy regimes for India, namely monetary targeting, inflation only targeting, and nominal income targeting and concluded that monetary targeting performed worst of the three regimes, while nominal income targeting may be the most preferred regime. Singh and Kalirajan (1999) using monthly data for the post reform period and using generalized impulse response functions, examined the link between monetary instruments, inflation and output growth and concluded that inflation needs to be controlled for a higher growth rate.

Whilst the monetary authorities and academics are debating ways and means of conducting monetary policy, there is a growing consensus in favor of lower inflation. The inflation rates in the developed countries, which are India's major trading partners, are in the order of 0-3 percent. Plausibly, in the same context, the Economic Survey 1997-98 stated 'In a growing economy 4 to 6 percent inflation rate could be regarded as acceptable'. In 1998-99, the economic survey advised restraint in the growth of money supply and fiscal deficit in addition to exercising a close watch on commodity prices in order to keep inflation under control. Most recently, the policy statement by the RBI Governor Bimal Jalan on monetary and credit policy for the year 1999-2000 (RBI 1999b) brought the issue of price stability to the forefront of the monetary policy debate. The Tarapore Committee on Capital Account Convertibility recommended a mandated rate of inflation for the three-year period 1997-98 to 1999-2000 in the average range of three to five percent.

In view of the foregoing discussion and the fact that monetary policy in India is at a cross road, the following vital empirical questions emerge. These questions need to be analyzed and addressed in order to gauge the effectiveness of monetary policy in India in achieving the RBI's stated objective of high growth and low inflation and to take a view on the potential monetary regime:

(1) Why should the RBI be concerned with inflation above anything else?

(2) How best can the inflation process in India be identified and modeled? More specifically, to what extent is inflation in India a monetary phenomenon and how much is it a supply side effect? Do all monetary aggregates behave alike or do they have different roles in determining inflation in India?

(3) What is the prospect of a money demand based monetary policy in India? What determines the money stock, is it money demanded or a reflection of money supply behaviour?

(4) How best can the behaviour of the RBI be explained with a policy rule for the existing monetary instruments? Specifically how best can CRR and interest rates be modeled for India in terms of goal variables and whether such policy stances are effective?

1.4 ORGANISATION OF THE THESIS

In order to shed light on the above issues, this thesis aims to undertake a systematic analysis of the behavioural relationships between inflation, output and monetary aggregates in India in the presence of other macroeconomic variables and policy instruments that are important in the decision process using annual data. It is organized as follows: The theory of inflation is presented and discussed in Chapter 2 and a theoretical overview of monetary regime choice and design is presented in Chapter 3. These two chapters provide the standard literature that forms the core of modern central banking.

The causal relationship between inflation and economic growth and the existence of any optimal level of inflation in the Indian context is examined in Chapter 4. Whether inflation influences economic growth indirectly through the savings and investment channel is also examined in this chapter. In order to identify the sources of inflation, the output gap and the aggregate demand and supply functions, are critically analyzed in chapter 5. The nature of demand and supply curves and the relationship between contemporaneous output gap and inflation shed light on the problem of whether the economy is affected more from supply or demand side factors. With the identification of the demand function and the output gap, the determinants of inflation are estimated based on a hybrid mark-up price model, which includes money and supply side variables.

In the absence of fully developed financial markets for government securities, the monetary aggregate remains as the main channel of policy transmission. In this context, three common monetary aggregates - base money (M0), narrow money (M1) and broad money (M3) are examined in Chapter 6. Specifically, Chapter 6 scrutinizes the robustness of the relationship between real output and monetary aggregates in a variety of specifications in order to determine whether monetary policy based on demand for money function can be meaningful in the Indian context. In view of the fact that the fiscal deficit is high and about 40 percent of commercial bank credit is directed, doubt arises as to whether what the RBI considers as demand for money may in fact be supply of money. Therefore, Chapter 7 attempts to analyze money supply behaviour of the RBI. Specifically, it estimates the base money supply function and the broad and narrow money multipliers in order to examine the fiscal dominance in money creation.

The main instrument for conducting monetary policy in India has been the cash reserves ratio (CRR). Interest rate instruments are also available but unlike the case in developed countries they have not been fully market determined, and are therefore expected to be comparatively less effective. Therefore, it is imperative to analyze the RBI's reactions to variations in major macroeconomic variables. Accordingly, an attempt is made in Chapter 8 to identify the reaction function of the RBI and the impact of the RBI's policy stances on major macroeconomic variables. The monetary policy instruments of CRR and annual yield on 1-5 year government securities (CGS1) and an indicator/supplementary target of the call money market rate (CMR) are analyzed and modeled in Chapter 8. It has been demonstrated that the RBI's policy stances have not been effective probably due to the lack of coordination in application of quantity controls through CRR and reserve money. Finally, Chapter 9 presents the concluding remarks and advocates a policy regime for India that should be dominated by inflation control as the main policy objective.

Annual data for the period 1970-71 to 1998-99 have been used for the quantitative analysis. The conclusions and inferences are based on the analysis of dynamic models, concepts of cointegration and error correction representation. A detailed description of data and quantitative methods are presented, respectively, in Appendix AA and AB of the thesis. Basic (untransformed) data is provided in Table AA.3, Appendix AA.

Chapter 2

The Theory of Inflation

2.1 INTRODUCTION

There has been a long debate over the causes of inflation. Does inflation originate in the goods market, the money market, or the labour market? Does it originate through some kind of expectation process? Several competing theories have been developed over time to explain, model, and cure inflation. Nevertheless, the controversy remains unresolved because no single theory is robust to changes with respect to periods of analysis, episodes of normal inflation and stagflation (high inflation associated with low growth) and episodes of high growth with low inflation. Tobin (1981) attributes this disarray to the important reason 'that there are several kinds of inflation and several diseases of which inflation is a highly visible symptom. Some countries suffer from one of these maladies and some from more than one simultaneously or sequentially. Some are cured without much effort, some are easy to cure, and some are intractable. There is no single sovereign remedy.' As a result, empirical analysis of the country-specific behaviour of inflation has become important in its own right.

The purpose of this chapter is to survey some of the popular theories of the inflation process in order to place the empirical analysis of the Indian economy in the right perspective. Some of the important previous surveys on inflation (Laidler and Parkin 1975, McCallum 1990) have considered old theories of demand-pull and cost-push phenomenon as rudimentary. The discussion in this chapter is not bound to any specific school of thought, and commences with demand-supply framework in section 2.2. In section 2.3 the popular Phillips curve phenomenon is discussed. Theories based on wage setting and price formation behaviour, developed to provide micro foundation to Phillips curve are discussed in section 2.4. The quantity theory approach and inflationary process are discussed in section 2.5. Section 2.6 attempts to cover the ideas dealing with the discretionary behaviour of monetary authorities and biased inflation. The process of inflation in real business cycle models is discussed in section 2.7. The ideas of the structural hypothesis of inflation are the subject matter of section 2.8. Inflation as an international process and the transmission of inflation from abroad is discussed in section 2.9. Finally, section 2.10 makes concluding remarks from the perspective of a developing country.

2.2 COST-PUSH AND DEMAND-PULL INFLATION

As the concepts of cost-push and demand-pull inflation have been at the heart of the inflation debate for a long time, it is appropriate to commence the discussion on short run inflation with these concepts. An appropriate tool to describe both concepts could be the system of aggregate demand and supply schedules given in Figures 2.1 and 2.2, which is based on the 'Six Equations Keynesian Model' (see Annexure 2.1 of this chapter for a brief discussion which is base on Sargent (1987: Chapter II). Solving the model yields upward sloping aggregate supply and downward sloping demand schedules in the output price plane. In Figures 2.1 and 2.2, aggregate supply schedule is represented with lines SS and demand schedule with DD. The initial equilibrium is represented with point A, the corresponding price P_0 and output Y_0.

The shift parameters for the supply schedule are the capital stock, money wage, prices of other inputs (raw materials like oil etc.), and the parameters of the production function. An exogenous increase in the costs of factors or raw material shifts the aggregate short-run supply curve to the left, thus increasing prices and reducing output and profitability. Figure 2.1 demonstrates "cost-push" through movement of equilibrium from point A to point B after the supply schedule shifts from S_1S_1 to S_2S_2. This is a situation of stagflation that may not be acceptable to policymakers, particularly central banks, and the money supply may be increased in order to restore output by stimulating demand.[19] The output level can be maintained only if there is an increase in demand, which shifts the demand curve to offset the

[19] If there were no increase in money supply to accommodate the cost-push then the position of the demand schedule, D_1D_1 (Figure 2.1) will remain unchanged and there is reduction in the real cash balance. With the money market equilibrium disturbed, the interest rate mechanism also begins to work. The increase in the interest rate results in crowding out effects. An increase in the money wage alone also leads to an increase in interest rates. Both factors become costly and reduce firms' profitability.

effects of supply shock. However, this situation further adds to a rise in price, by the movement of point B to E.

Figure 2.1: Cost-push inflation

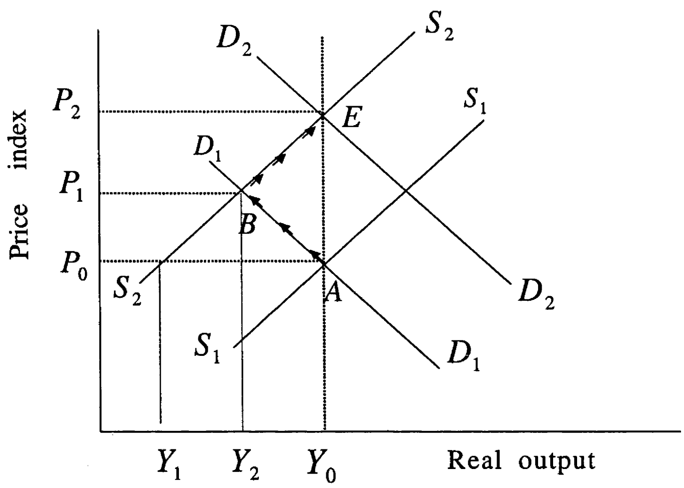
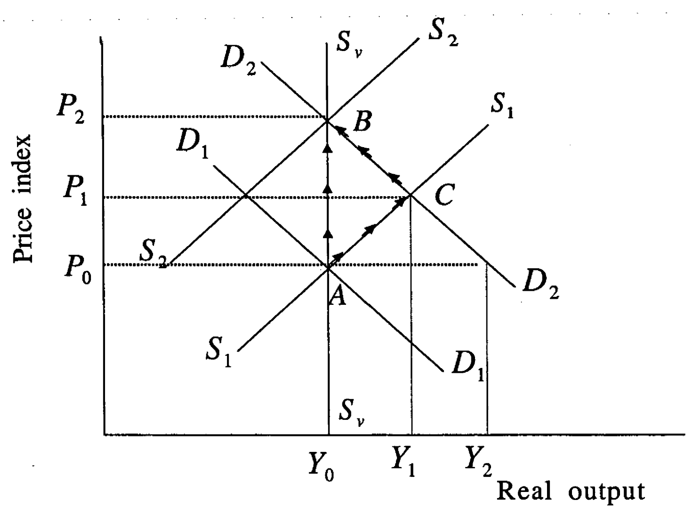


Figure 2.2: Demand-pull inflation



With the monetary accommodation of cost-push, monetarists claim inflation to be a monetary phenomenon. This also presents the well known dilemma of policy makers in fighting adverse supply shocks: any attempt to fight a price rise by reducing the money supply further reduces output, and attempts to maintain output by the use of expansionary policy means a higher price level. On the other hand, a positive technology (supply) shock leads workers to increase real wages (in line with improvements in the marginal product of labour), leading to increased output and a fall in prices; in turn, the subsequent shift of the demand schedule would determine the final price level.

The "demand-pull" parameters[20] are government expenditure, taxes, money supply and expected inflation. In the case of an open economy, exports can be included in "demand-pull" parameters. An increase in government expenditure and money and a decrease in taxes shift the aggregate demand schedule to the right from D_1D_1 to D_2D_2, causing a demand gap of $Y_0 Y_2$ in Figure 2.2. The general price level jumps accordingly. If the demand-pull is due to an increase in money supply the interest rate falls. If the demand-pull is due to a fall in taxes or a rise in government expenditure or in expected inflation, the interest rate rises. Thus, the real profit of firms depends on the increase in the marginal product of labour, and the real cost of capital will rise or fall depending on the cause of the demand-pull. To meet excess demand, firms attempt to employ more labour by raising the wage, while workers base their supply on the expected real wage (W / P^e), with P^e being the expected price assumed to adjust with temporal lag. Workers suffer from money illusion and misread the new money wage as the real wage, and supply more labour; output increases to Y_1 through movement along AC.

However, it can be argued that point C is not stable. After a certain period, workers realize their real wage has not risen sufficiently, and demand higher nominal

[20] Gordon (1977) demarcated "*demand-pull inflation*" between Keynesian and monetarist schools of thoughts depending upon the causation of demand-pull, whether it was a fiscal pull or a monetary pull. He pointed out two major differences. First, the quantity theory has a dynamic setting with an upward shift in DD being fueled by continuous money injection, while Keynesian inflation could explain the increase in the price level from P_0 to P_1 or P_2 if the dynamic process were stable and explosive inflation with unstable parameters. However, Keynesian inflation could not explain stable inflation without the implicit assumption of unlimited supply of idle money or passive monetary accommodation. The second difference comes from the assumption of vertical supply curve S_v in quantity theory, which is allowed to explain continuous money-fueled inflation shifting the economy in Figure 1a from A to B and further north along the vertical supply curve. In contrast Keynesian models emphasize income distribution during inflation with several assumptions like money illusion, lags etc. In case of cost-push inflation Gordon (1977) also believes that only monetary accommodation can restore original output, thus sustained inflation could become 'always and everywhere a monetary phenomenon' in the words of Friedman (1963 p.17).

wages corresponding to the increase in price. At the new nominal wage, the supply curve shifts to the left from S_1S_1 to S_2S_2 along CB, causing a further increase in the general price level as a result of adjustment of the supply function to a higher cost (Gordon 1977). Subsequent to increased nominal wages, induced demand–pull can add to a successive shifting of the demand curve until workers are satisfied with living conditions.

"Cost-push" and "demand-pull" inflation have different characteristics. While the factors cause a price rise in both cases, their effects on output, employment and real wage are opposite. Output falls in the "cost-push" case but rises in the "demand-pull" case. This difference in the effects of inflation can help identify whether it is "demand-pull" or "cost-push" inflation (Phelps 1961).

It may be argued that conflict in the demand and supply side stories of inflation arises because of the difference in theoretical perceptions. When demand and supply are analyzed in a system (as in Blanchard and Fischer (1989) chapter 10), Benassy (1986), and Gordon (1977) among several others), the problem reduces to the identification of the type of shock (demand or supply) that hits the economy, the speed of adjustment, and the subsequent actions (accommodation or activism) taken by policy makers.

2.3 PHILLIPS CURVE: THE TRADE-OFF THEORY OF INFLATION

A variant of excess demand inflation is a trade-off continuum with increasing inflation for additional employment and production. In the standard Keynesian model, the wage is given at any point of time and there is no provision to generate subsequent revisions in wages. However, A.W. Phillips suggested that recent values of the unemployment rate could explain the nominal wage rate in any period (Phillips 1958).[21] The hypothesis of the Phillips curve is that the change of the nominal wage in period t depends negatively on the unemployment rate. Thus, the original Phillips curve can be represented algebraically as follows[22], where $w_t = \log W_t$ and $UN_t =$ unemployment rate (in fraction) for period t:

$$\Delta w_t = f(UN_{t-1}), \; f' < 0. \tag{2.1}$$

[21] Laidler and Parkin (1975) note several previous studies on wage inflation and unemployment.

[22] Important work in formalization of this relationship is attributed to Lipsey (1960).

In the absence of technical progress, λ, the price level and the money wage rate will each grow in the steady state at the same rate, as does the money stock. With technical progress, the money wage will grow at a rate that exceeds the price-level P_t by a fixed amount equivalent to the rate of technical progress. The inflation rate will be high if, and only if, the growth of nominal wage is high; and consequently price and wage inflation denoted by $\Delta \log P_t$ and $\Delta \log W_t$, will be perfectly correlated across steady states (McCallum 1989). This relationship implies a similar relationship between $\Delta \log P_t$ and unemployment:

$$\Delta p_t + \lambda = f(UN_{t-1}) \tag{2.2}$$

where $\Delta p_t = \Delta \log P_t$.[23] This emphasizes the existence of a trade-off between steady state values of inflation and unemployment. An economy cannot permanently reduce its inflation rate without creating additional unemployment. However, just a simple form of a stable Phillip curve cannot explain the existence of phenomena like states of low growth/ high inflation (stagflation) or high growth/ low inflation.

Friedman (1966, 1968) and Phelps (1967) made important modifications to the original Phillips curve. First, it was argued that it is the real wage that matters for employment rather than the nominal wage. The growth in nominal wages was replaced by growth in real wages, which led to the widely known Augmented Phillips curve in the current form. The second observation made was that the trade-off between inflation and unemployment was not stable under changing inflationary expectations and a distinction should be made between the short and long run Phillips curve effects of an unanticipated acceleration of aggregate nominal demand. Thus, with expectation of inflation formed at the end of period t-1 represented by $\Delta p_{t|t-1}$, the expectations-augmented Phillips curve can be written as wage growth equal to the sum of expected inflation plus a function of unemployment:

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[23] As a general convention, in this thesis, a Δ before a variables denotes first difference and variables represented with small case letter represents that the variable is taken in log. Thus Δp represents growth in price or inflation in fraction.

$$\Delta w_t = f(UN_{t-1}) + \Delta p_{t|t-1} \tag{2.3}$$

With the mark-up wage given by $\Delta w_t = \lambda + \Delta p_t$ in the steady state, the modified Phillips curve can be written in the general form of:

$$\Delta p_t + \lambda = f(UN_{t-1}) + \Delta p_{t|t-1} \tag{2.4}$$

This relationship implies that the short-run Phillips curve shifts in a parametric fashion when the expected rate of inflation changes; higher expected inflation shifts the curve up. Alternative expected rates of inflation would correspond to alternative Phillips curves and different extents of money illusion.

At the steady state $\Delta p_t = \Delta p_{t|t-1}$, the Phillips curve $\Delta p_t + \lambda = f(UN_{t-1}) + \Delta p_{t|t-1}$, reduces to $\lambda = f(UN)$, a relationship independent of inflation. In the long run, the Phillips curve is vertical. In other words, with fully anticipated inflation, there is no real effect. Friedman and Phelps labeled the unemployment rate existing in this steady state as the "natural" rate of unemployment, which has the property of remaining constant at each rate of inflation as long as that rate is fully anticipated (Frisch 1983:49). Friedman (1976) argued that the only way unemployment can be kept below the natural rate is by ever-accelerating inflation, which always keeps current inflation ahead of anticipated inflation. However, 'since you can't fool all of the people all of the time, the true long-run Phillips curve is vertical'.[24]

It is argued, and empirically shown in some prominent studies with adaptive expectations, that there is only partial adjustment in wage settings to expected inflation (Solow 1969, Gordon 1970). However, Sargent (1973) and McCallum (1976) pointed out that if expectations were rational and models consistent, almost full adjustment could be obtained. This leads to a modified Phillips Curve as follows with α lying in the open interval of zero and one:

$$\Delta w = \Delta p_t + \lambda = f(UN_{t-1}) + \alpha\ \Delta p_{t|t-1} \tag{2.5}$$

[24] This is also known as the non-accelerating inflation rate of unemployment (NAIRU): the unemployment rate at which inflation is neither accelerating nor decelerating (Dornbusch and Fischer 1994:512).

However, Friedman (1976:229), reacting on the econometrics of testing natural rate hypothesis, observed that keeping inflation on the left hand side and unemployment or a function of unemployment on the right hand side as an exogenous variable implies unemployment could persist forever. 'In effect, the implicit assumption that unemployment can take different values begs the whole question raised by the accelerationist hypothesis. On a statistical level, this approach requires putting unemployment $f(UN)$ or a function of that on the left hand side and not Δp' Friedman (1976:229).

Another important modification in the Phillips curve came through the well-known Okun's Law. Okun (1970) studied the trade-off between unemployment and detrended output levels for the U.S. economy from 1950 to 1984 and demonstrated a negative relationship between unemployment and the departure of gross national output from potential. A rise in the unemployment rate from the natural rate would correspond to the negative departure of output from the trend (negative output gap) and vice versa. Therefore, combining Okun's Law with the augmented Phillip's curve, gap model of inflation, a relationship between inflation and output gap can be written as follows:

$$\Delta p_t = \delta + \beta \ f\ (y_t - y_t^p)_{t-1} + \alpha \ \Delta p_{t|t-1} \tag{2.6}$$

where y_t is actual output and y_t^p is the potential output corresponding to the natural rate of unemployment both taken in their logs such that the output gap (GAPY) as fraction of potential output can be expressed as $y_t - y_t^p = GAPY$. With this specification, the so called "negatively" sloping Phillips curve in an inflation-unemployment plane is now an "upwards" sloping curve in the inflation-output plane, because of the negative relationship between unemployment and the output gap. The output gap has recently been used in several studies to model inflation (see de Brouwer and Ericsson (1995), and Coe and McDermott (1997) for example).

Digressions in the Phillips Curve Debate

In his Noble lecture, Friedman (1977a) discussed three stages of the Phillips curve. The first is the "stable" Phillips curve, in which there is a stable trade-off between inflation and unemployment. The second stage concerns the "natural rate hypothesis" where the distinction is made between the short-run Phillips curve corresponding to a given inflationary expectation and the long-run expectations adjusted Phillips-curve, which is vertical.[25] Friedman conjectured a third stage (which is not fully explored in the literature) to accommodate the episodes of higher inflation accompanied with higher unemployment in the seven countries of France, Germany, Italy, Japan, Sweden, United Kingdom, and the United States during the period of 1960-75, which could be explained by a positively sloped Phillips curve in the inflation-unemployment plane.

Friedman considered the positively sloped Phillips curve a transitional outcome of prolonged political and institutional rigidities. In the long run, once the political and institutional arrangements adjust to new realities and the transition period is over, unemployment will be largely independent of the average rate of inflation. A high inflation rate is not likely to be steady during the transition period because it disturbs the anticipations of economic agents. Further, in order to arrest high inflation, the government engages in various conflicting policies, which further exacerbates the variations in anticipated inflation. Increased variability of actual and anticipated inflation adversely affects unemployment.

Some authors working on stagflation in developed countries do not agree with Friedman's (1977a) hypothesis that high inflation is likely to increase inflation variability, which in turn slows down growth (for example Fischer 1981, Bruno and Sachs 1985). The emphasis in such studies is on the supply side of the economy, where it is agreed that shocks to supply side variables like raw material prices accounted for much of the variability in inflation and high inflation during the 1970s. The idea is that the shift in the short-run supply curve does not solely depend on changes in inflationary expectations; other variables also shift the short-run supply curve. Bruno and Sachs (1885:204) estimated the augmented Phillips curve for Belgium, Canada, Denmark, France, Germany, Japan, the United Kingdom and the United States for the period 1961-81, with inflation as the left hand side variable and unemployment and other variables like import price, changes in trend productivity growth, and the real wage gap as the right hand side of the equation. Their results show a significant negative coefficient for unemployment in four countries (Belgium, Germany, USA and UK), an insignificant negative sign for three countries (Canada,

[25] Some authors consider a medium-run Phillips curve, which is steeper than the short-run trade-off Phillips curve.

Denmark and Japan), and an insignificant positive sign for France with correct signs of shift variables in all cases. Interestingly, in the basic Phillips curve without other variables, the coefficient of unemployment is insignificant in all cases and has a positive sign in the case of Denmark and France. Thus, the supply-side effect on inflation is well supported but the robustness of the trade-off between unemployment and inflation remains a doubtful proposition. The question then becomes: should the state of the trade-off be treated as an empirical problem rather than a theoretical result and, even for the same economy, should it be revised periodically?

Bruno and Sachs (1985) provide a detailed analytical account of the supply side economics of inflation. Their analysis of factor adjustment to supply-price shocks is relevant in the Indian context. A permanent increase in the relative price of a factor of production like raw materials shifts the production frontier towards the origin. Since capital is fixed in the short-run, the new equilibrium output and profit depend on the relative flexibility of real wages and the legal system regarding labour laws. Consider a situation in which the wage is indexed to the price index and labour laws do not allow employers to fire workers easily. With a rigid real wage, unemployment should increase but does not due to the protective labour laws. Employment could also be forced to remain unchanged due to technological reasons (for example putty-clay technology). The result is a fall in profit and output. The market clearing output is lower, although potential output based on the capital and labour employed has not changed. This causes widening in the output gap with actual output falling below potential (thus a fall in the output gap in algebraic sense). In the long run, if raw material prices revert and expectations are corrected, the system can back track to the original frontier.

2.4 MICROFOUNDATION TO THE PHILLIPS CURVE: WAGE AND PRICE SETTING BEHAVIOUR

Although, the augmented Phillips curve is a widely used form of aggregate supply function, there are several other competing supply functions. These include *inter-alia*, the monetary misperception based model of Lucas(Jr.) (1972, 1973); the sticky-wage theory based model of Fischer (1977); the relative price theory based models of Taylor (1979), Calvo (1983), Fuhrer and Moore (1995); and the p-Bar model of McCallum (1994). These models are mostly directed to provide a micro foundation to the Phillips type relationship and better understanding of the inflationary process. Some are briefly discussed below.

Lucas Flexible Price, Monetary Misperception Model

In the monetary misperception type of model, the Phillips-type correlation results from the 'mistaken' belief of individuals about the macroeconomic conditions due to incomplete information about the state of the economy. The individual sellers, who observe changes in the prices of their product, may not completely know whether this was due to economy wide change or to a change in the relative demand for their product. Therefore, undecided about the quantum of increasing output the individual sellers settle for an output corresponding to an intermediate price between the economy wide average expected price and the price of their product. The misperception arises because, not knowing the current economy wide price, the individual seller forms expectations based on past information. In a simplified aggregate model, this comes out to be similar to the augmented Phillips curve, which can be expressed as

$$P_t = P_{t|t-1} + c\,(Y_t - Y_t^{P}) \tag{2.7}$$

Here $P_{t|t-1}$ is the forecast of the general price for the period t, made at the end of period t-1 and P_t is the average aggregate price level of all firms, Y_t^P is the aggregate potential output of all firms, and Y_t is the actual aggregate output of all firms. Taking variable in log and after a little algebra the relationship can also be expressed as

$$\Delta p_t = \Delta p_{t|t-1} + c\,(y_t - y_t^{P}) \tag{2.8}$$

Output is high when actual inflation is greater than the expected value. This approach is different[26] because of the way the model is derived based on individual mistaken perceptions about the economy wide price. Therefore, the relevance of the theory is measured by the information gap. If timely data on monetary stock and prices of other goods is available, as is now the case in most economies, the relevance of the

[26] The difference between the Friedman-Phelps augmented Phillips curve and the Lucas supply curves lies in the fact that the former stresses the time lag between the expectation formation and the inflation realization, while the latter stresses the discrepancy of each local and aggregate price.

theory would diminish. With no mistake in perception about the money stock and hence the shift in aggregate demand curve, the seller would set the corresponding price and the Lucas supply curve would be vertical and free of rigidity. One important implication of the Lucas supply curve is the policy ineffectiveness theorem under rational expectation shown in Sargent and Wallace (1975).

Nominal and Real Rigidities and Sticky Prices

There are several other models commonly known as 'New Keynesian tradition' which seek to exploit rigidities in labour and goods market to explain short run real effect of monetary policy and hence the Phillips curve phenomenon. The paradigm of the literature dealing with this tradition can be summarized in the following three groups. (1) Labour contracts (wage bargaining) are made in nominal money terms through wage setting institutions, where different firms set their wages at different points of time and renegotiate at different intervals (staggered contracts) leading to sticky nominal wages (nominal wage rigidity). Producers prefer long-term contracts because negotiating is costly. In this situation, real wage is not equal to the marginal product of labour all the time and, therefore, real wage is also considered sticky.

(2) Monopolistically competitive firms face small 'menu costs' when they change prices such as those required to prepare and post new price lists and costs of annoying customers (Akerlof and Yellen 1985, Mankiw 1985, Ball, et al. 1988, Blanchard 1986). Therefore, monopolistically competitive firms do not have incentive to cut their prices when demand for their goods declines, which leads to stickiness in prices (sticky prices). (3) Firms may want to pay employees wages above the market clearing wage, in order to attract and maintain a quality workforce and to ensure they work hard and remain loyal (efficiency wage) (Yellen 1984). This also means, even with persistent unemployment, firms do not reduce wages because doing so may reduce productivity resulting in stickiness in real wages and real price of firms' output (real rigidity). This theory, though helping to explain the existence of unemployment, by itself, does not explain slow changes in the nominal wage.

However, it is argued that real rigidities such as efficiency wages when considered together with price rigidity caused by menu costs may enhance nominal wage rigidities (Ball and Romer 1990). Menu costs prevent prices from falling in response to a reduction in aggregate demand; rigidity in real wages prevents wages from falling in response to the resulting unemployment. The failure of wages to fall, keep firms' costs high and thus ensures they have little incentive to cut prices (Mankiw 1990). This provides a new explanation for Keynesian disequilibrium.

In practice, both nominal and real types of rigidities can be observed. Therefore, the effectiveness of monetary policy in the short run is restored. However, one of the main issues in this chapter is to review theories which help explain the inflation process. What makes wages or prices change slowly and inflation persist? The literature identifies two sources of inflation persistence. Inflation can display persistence if the money growth rate displays persistence as would be predicted by quantity theory, discussed later. Walsh (1998:215) observes that if this were the only sense in which inflation appears to exhibit persistence, it could easily be explained within the context of flexible price models. If conduct of monetary policy is such that it introduces a high degree of serial correlation in money growth, it will get reflected in the behaviour of inflation. However, there can be inflation persistence in a non-monetary sense as well, as demonstrated by models based on staggered wage setting and wage contracts. Some of these models demonstrate inflation persistence, while others demonstrate price level persistence. Therefore some of the widely cited models, such as those developed by Fischer (1977), Taylor (1979), McCallum (1994) are discussed below.

Fischer's Model

The simplified idea behind Fischer's (1977) two-period model of staggered wage setting is that sellers are split into two groups setting nominal wages that stay in effect for two periods. Doing this brings in wage/price stickiness. However, wages for the two periods would not be the same but would be at the market clearing level. Thus, for one half of the workers, wages are set at the end of the period t-1, which will continue for period t and t+1 and for the other half wages are set at the end of period t-2, which would continue in period t-1 and t. The supply of the output is assumed to be a decreasing function of the real wage. Let y_t be log of output, $\bar{y}_t$ full employment output, w_t the log of nominal wage, z_t the log of real wage and p_t the log of price in period t such that $z_t = w_t - p_t$ is the real wage for some group and $\bar{z}_t$ the market clearing value of z_t. Then, the expected value of the market clearing nominal wage at the end of period t-1 will be $\bar{z}_{t|t-1} + p_{t|t-1}$, which will prevail for periods t and t+1. For the other half of the workers, the period t nominal wage would have been set at the end of period t-2 at the level of $\bar{z}_{t|t-2} + p_{t|t-2}$, which continued in periods t-1 and t. Using these relationships, and aggregating the output supply of the two groups, Fischer postulated a log-linear aggregate supply function of the form:

$$y_t - \bar{y}_t = \alpha_0 + \alpha_1[0.5\{p_t - (\bar{z}_{t|t-1} + p_{t|t-1})\} + 0.5\{p_t - (\bar{z}_{t|t-2} + p_{t|t-2})\}] \qquad (2.9)$$

With a demand function of the form of simple velocity equation, and solving the model rationally, Fischer (1977) demonstrated that monetary policy is not neutral in the short-run but supports the natural rate hypothesis. However, the model is criticized for its assumption that output is negatively related to the real wage on the ground that real wages do not exhibit the counter-cyclical behaviour predicted by Keynes' General Theory (Mankiw 2001). As discussed earlier, in Keynes model, when the central bank contracts the money supply and prices fall, real wages rise, leading to a lay off of workers and hence the theory exhibits a short-run trade-off between inflation and unemployment. However, Mankiw (2001) considered this argument patently false. In his opinion, firms lay off workers after monetary contractions not because real labour costs are high but because they cannot sell all of the output they want at the prevailing price. Prices do not clear goods market; and firms appear to have some degree of market power as discussed earlier.

Taylor's Model

Taylor (1979, 1980) used another version of the wage bargain model, which is characterized by its forward-looking aspect. The basic model is also discussed in Hall and Taylor (1997:438-440). Recognizing that output is a function of employment, a simplified version of this type of contract is as follows. As above the wage contracts are again staggered in two (or more) periods by two (or more) groups and stay for two periods. Let x_t be the log of the contract wage, in period t and the other symbols remain the same as used in discussing Fisher's model earlier. This time the average wage is the average of the contract wage signed in the previous year for the first group, which is still outstanding, and the contract wage signed in the current year for the second group, which will also be in effect for the following year. Thus, the aggregate wage is the geometric average of the contract wage in two periods.

$$w_t = 0.5(x_t + x_{t-1}) \tag{2.10}$$

However, the critical part of Taylor's approach is the way in which x_t is set taking into account the expected future average wage and the expected future excess demand (or equivalent unemployment) based on the information available at the end of period t-1, which means $x_t = x_{t|t-1}$. For that purpose, the contract wage relationship chosen is of the form:

$$x_t = 0.5(w_t + w_{t+1|t-1}) + 0.5\delta\ [(y_{t|t-1} - \bar{y}) + (y_{t+1|t-1} - \bar{y})] \tag{2.11}$$

Equations of aggregate wage (2.10) and of contract wage (2.11) together yield the supply curve as:

$$x_t = 0.5(x_{t-1} + x_{t+1|t-1}) + \delta\ [(y_{t|t-1} - \bar{y}) + (y_{t+1|t-1} - \bar{y})] \tag{2.12}$$

To write Taylor's model in terms of prices assuming a constant markup $q = 0$, the log price level can then be expressed as $p_t = w_t + q = w_t$. With this assumption, noting that now $p_t = 0.5(x_t + x_{t-1})$ and expressing an expectation error $\eta_t = p_{t|t-2} - p_t$, the price equation can be written as follows:

$$\begin{aligned} p_t &= 0.5(p_{t-1} + p_{t+1|t-1}) + \\ &\quad 0.5\delta\ [(y_{t|t-1} - \bar{y}) + (y_{t+1|t-1} - \bar{y}) + (y_{t-1|t-2} - \bar{y}) + (y_{t|t-2} - \bar{y})] + 0.5\eta_t \end{aligned} \tag{2.13}$$

In terms of inflation the equation can be expressed as follows:

$$\Delta p_t = \Delta p_{t+1|t-1} + \delta\ [(y_{t|t-1} - \bar{y}) + (y_{t+1|t-1} - \bar{y}) + (y_{t-1|t-2} - \bar{y}) + (y_{t|t-2} - \bar{y})] + \eta_t \tag{2.14}$$

The value of p_t is influenced by expectations of the future price and also the price level of the previous period displaying inertia effect. However, there is no inertia in the rate of inflation. Instead, significantly, any policy of disinflation is costless and may be beneficial. Thus, the model can result in violation of the natural rate hypothesis. However, Fuhrer (1994) characterized Taylor's specification as satisfying the first-order natural-rate hypothesis (average output is independent of the average level of inflation) but not the second-order version (average output does depend on the rate of change of inflation). The model could not generate the kind of inflation persistence as shown by the data in the Fuhrer (1994) experiment.

Taylor (1979) used a velocity equation in wage, money and excess demand to represent the demand equation and a function of aggregate wage as a policy rule of money supply to solve the dynamic rational expectation model. The resulting price (wage)[27] equation is obtained in terms of the realized values of the prices (wage) and supply shock demonstrating the usefulness of the model over the simple augmented Phillips curve. The forward-looking part corresponds to the demand effect on the wage. The wage persistence comes from the backward looking part of the equation and depends on how accommodative aggregate demand policy is in relation to wage contract adjustments which are "too inflationary".

P-Bar Model

McCallum (1989:189, 1994) has criticized the Taylor type model on several accounts considered important to specification of price. To McCallum, adherence to the "natural rate" hypothesis is a very important characteristic of the price model, which means monetary policy should not have a permanent effect on the output gap and the potential output for calculating the output gap should be tied to the inputs of production rather than to deterministic trend. Secondly, in the view of McCallum, money should not be excluded from the price equation. McCallum (1994) has revived[28] the p-bar model in which $\bar{p}_t$ is the price level consistent with $y_t = \bar{y}_t$. The actual price level in the p-bar model is assumed to adjust as follows:

$$\Delta p_t = p_t - p_{t-1} = \gamma(y_{t-1} - \bar{y}_{t-1}) + (\bar{p}_{t|t-1} - \bar{p}_{t-1|t-1}) \qquad (2.15)$$

The adjustment parameter γ is assumed positive. The actual price level increases if output exceeded the natural rate in the previous period, or if $\bar{p}$ itself is expected to increase. In order to capture the lagged deviations of the actual level of output from the natural rate and the lagged deviation of the expected value of p-bar to the expected value of p-bar, the $\bar{p}$ adjustment equation is written as follows:

[27] Taylor (1977) derived the supply equation in terms of wage instead of price.

[28] McCallum (1994) lists a number of authors who have previously worked on a similar line.

$$p_t - \bar{p}_{t|t-1} = \gamma(y_{t-1} - \bar{y}_{t-1}) + (\bar{p}_{t|t-1} - \bar{p}_{t-1|t-1}) \tag{2.16}$$

Factors determining p-bar are obtained from an aggregate demand function of the following specification obtained from IS-LM framework, where υ_t is a disturbance term.

$$y_t = \beta_0 + \beta_1(m_t - p_t) + \beta_2(p_{t+1|t-1} - p_{t|t-1}) + \beta_3 y_{t-1} + \upsilon_t \tag{2.17}$$

On solving (2.17), for the realized value of p_t and applying the condition that p-bar corresponds to the natural rate of output, gives a value of p-bar as follows:

$$p_t = \frac{1}{\beta_1 + \beta_2}[\beta_0 + \beta_1 m_t + \beta_2 p_{t+1|t-1} + \beta_3 y_{t-1} + \upsilon_t - y_t] \tag{2.18}$$

$$\bar{p}_t = \frac{1}{\beta_1 + \beta_2}[\beta_0 + \beta_1 m_t + \beta_2 p_{t+1|t-1} + \beta_3 y_{t-1} + \upsilon_t - \bar{y}_t] \tag{2.19}$$

Using the difference operator Δ, equation (2.19) implies

$$\Delta\bar{p}_{t|t-1} = \frac{1}{\beta_1 + \beta_2}[\beta_1 \Delta m_{t|t-1} + \beta_2 \Delta p_{t+1|t-1} + \beta_3 \Delta y_{t-1} - \Delta\bar{y}_{t|t-1}] \tag{2.20}$$

Then the inflation rate is obtained by plugging the value from (2.20) into equation (2.15) as follows.

$$\Delta p_t = \gamma_1(y_{t-1} - \bar{y}_{t-1}) + \frac{1}{\beta_1 + \beta_2}[\beta_1 \Delta m_{t|t-1} + \beta_2 \Delta p_{t+1|t-1} + \beta_3 \Delta y_{t-1} - \Delta\bar{y}_{t|t-1}] \tag{2.21}$$

This is the main equation of price determination in the p-bar model designed to ensure that the natural rate hypothesis holds, which can be demonstrated after some algebraic manipulations. The model has the appearance of Taylor's type models. However, the presence of the expected rate of money growth makes it significantly different from the other models. This model also makes prices but not inflation as persistent.

The Current State of Phillips Curve

The inflation-unemployment trade-off is so integral to monetary policy, at least for some economists, that Alan Blinder (1997) has called the reliability of the modern Phillips curve the 'clean little secret' of macroeconomics. Such a trade-off is important for monetary policy because of the claim that changes in monetary policy push output and inflation in two opposite directions in the short run. A monetary injection first increases output and employment (sticky price effect), and later increases the price level. Thus, monetary policy has both real and nominal effects.

However, in a recent article Mankiw (2001), considered the trade-off between inflation and unemployment as inexorable and mysterious. Inexorable, because it is impossible to make sense of the business cycle, and in particular the short-run effects of monetary policy, unless admitting to the existence of such a trade-off. Mysterious because of the lack of empirical support for such a trade-off. 'The combination of low inflation and low unemployment enjoyed by the United States in the late 1990s suggests to some people that there is no longer a trade-off between the two variables, or perhaps that it never existed at all' (Mankiw 2001).

Whatever stability of the augmented Phillips curve has been observed in data, it is mostly limited to the models, which include adaptive expectations. The rational expectations version of models with forward-looking behaviour lead to puzzling results not at all supported by data (Roberts 1997, Mankiw 2001) and the assumptions of rational expectation itself becomes questionable. However, the concept of rational expectations has penetrated theoretical economics so much that several theorists would not accept anything short of a rational model.

Mankiw (2001) examines four versions of the Phillips curve, two with adaptive expectations and two with rational expectations Representing inflation with π_t $(=\Delta p_t)$ and natural rate of unemployment with $\overline{U}$, the four versions of Phillips curves examined by Mankiw (2001) are presented below in equations 2.22 to 2.25 (Table 2.1). The new Keynesian forward-looking model (equation (2.24), similar to the models derived by Taylor (1979) and Calvo (1983), considered to be grounded more firmly in theory, is the favourite model under scrutiny. In his simulation Mankiw assumes an impulse response function of inflation following a contractionary monetary shock and calculates the inferred (or implied) impulse response function for unemployment by using each of these Phillips curves. The expectation from the model is to generate data showing an increase in the unemployment rate following a monetary contraction.

The figures in Table 2.1 indicate that the theoretically sounder model given in equation 2.24 generates an impulse response completely opposite to expectations. This is puzzling; 'given a plausible impulse response function for how inflation reacts to monetary policy shocks, the new Keynesian Phillips curve implies a completely implausible impulse response function for unemployment' (Mankiw 2001). With a similar model, Ball (1994a) demonstrated that credible disinflation can cause a boom.

Table 2.1 Impulse response function to a contractionary monetary shock

Traditional backward looking model $$\pi_t = \pi_{t-1} - 1/8(U_t - \overline{U}) \quad (2.22)$$

Backward-looking model with hysteresis $$\pi_t = \pi_{t-1} - 1/8(U_t - \overline{U}), \quad \overline{U}_t = 0.9\,\overline{U}_{t-1} + 0.1\,U_{t-1} \quad (2.23)$$

New Keynesian forward-looking model $$\pi_t = \pi_{t+1|t} - 1/8(U_t - \overline{U}) \quad (2.24)$$

Fuhrer-Moore Model $$\pi_t = (\pi_{t-1} + \pi_{t+1|t})/2 - 1/8(U_t - \overline{U}) \quad (2.25)$$

Quarter	0	1	2	3	4	5	6	7	8	9	10
Inflation	0.0	0.0	-0.1	-0.3	-0.6	-1.0	-1.4	-1.7	-1.9	-2.0	-2.0
Unemployment according to equation											
(2.22)	0.0	0.0	+0.8	+1.6	+2.4	+3.2	+3.2	+2.4	+1.6	+0.8	0.0
(2.23)	0.0	0.0	+0.8	+1.7	+2.6	+3.7	+4.0	+3.5	+3.0	+2.3	1.6
(2.24)	0.0	-0.8	-1.6	-2.4	-3.2	-3.2	-2.4	-1.6	-0.8	0.0	0.0
(2.25)	0.0	-0.4	-0.4	-0.4	-0.4	0.0	-0.4	-0.4	-0.4	-0.4	0.0

Source: Mankiw (2001), Table 1

Based on the above results and the existence of evidence of high growth with low inflation, it can be concluded that theoretical underpinning of a trade-off between inflation and employment is an unfinished agenda and practicing economists still have to rely on data more than theory.

2.5 QUANTITY THEORY AND INFLATION

In the absence of a clear-cut process to resolve the demand-supply and price wage nexus, the Monetarist School led by Milton Friedman presented an alternative explanation of inflation, declaring 'inflation is at all times and everywhere a monetary phenomenon' (Friedman 1963:17). In the pure form of quantity theory, inflation is attributed to an excessive rate of growth of monetary aggregates, more specifically excessive money growth relative to the growth of real output. More money chasing few goods results in rising prices.

The question typically raised by critics is why the monetary authorities would resort to excessive growth of monetary aggregates? The explanation to this question is intellectual errors in the estimation of money supply requirements and judgments about the nominal rate of interest to be maintained and the amount of credit to be created for a stipulated rate of output growth. A related explanation is the discretionary policy and incentive for time inconsistency discussed in Section 2.6. Precisely estimated money demand function and stability of the velocity of money are central to the studies of monetary inflation. In its simplest form, money stock[29] M, nominal income $P\,Y$ (where P is price level and Y is the real income), and velocity V are linked through the relationship: $MV = PY$. Velocity of money is the number of times the money stock turns over each year in financing payments made to purchase the economy's output. Taking logs and totally differentiating both sides, this equation can be written in growth form of variables. With lower case letters m, v, p, and y representing logs of money, velocity, price and output while a Δ before the variable indicating change, the equation marked as above can be transformed in an inflation (π) accounting equation in terms of growth of money, output and velocity as:

$$\pi = \Delta p = \Delta m - \Delta y + \Delta v \tag{2.26}$$

The monetarists claim that inflation is predominantly a monetary phenomenon, implies that the velocity changes are very small. However, there is no economic reason to believe that velocity should be constant. In fact, if the income elasticity of real money is not unity then velocity can change due to that reason itself, without the influence of other reasons like financial innovations. Further, it is important to note that velocity should be a stationary process in order to assume a stable relationship between inflation, money growth and output growth. In addition to the assumption of stability of money demand function and small changes in velocity, there are several other important assumptions associated with the monetarist model of inflation in its original form. The role of interest elasticity is considered insignificant, money supply

[29] It is not clear whether it should be cash balance or a broader aggregate of money.

is exogenous and fully under control of the monetary authorities, whereby a money multiplier can be used as an effective policy instrument. There is unidirectional causality from money to price and not vice versa. Similarly, causality from money to income is assumed to be unidirectional, an assumption supported by Sims (1972) causal study, which is not widely accepted. Finally, in the long-run, money is considered neutral.

Friedman (1970), and Sargent and Wallace (1975), among others, have modified the static monetarist model presented above in different and important ways to incorporate real interest rate, wealth effects, inflationary expectations and money surprises. Dynamic monetarist models have been analyzed with both adaptive expectations as well as rational expectations. One of the popular early analyses in the adaptive version was developed by Cagan (1956) to explain hyperinflation. However, McCallum (1989:139) criticized the econometric formulation of Cagan's problem. McCallum (1998:Chap 9) applied dynamic rational expectations hypothesis to the underlying money demand model of Cagan (1956) with distributed lag type money supply behaviour. The analytical solution to such a specific problem leads to one to one correspondence between money growth and price, a property in line with quantity theory.

In the rational expectation tradition, one of the major assumptions is that production depends on the surprises in prices ($P_t - P_{t|t-1}$). Model of supply and demand introduced by Lucas(Jr.) (1972) of the form $y_t^s = y_0 + \alpha(P_t - P_{t|t-1})$; $y_t^d = \gamma M_t - \beta P_t + \varepsilon_t$ has extensively been used in literature for analyzing output behaviour with the disturbance term in the demand equation, assumed to be either a white noise or following an autoregressive process. In a simple analysis with disturbance as white noise, Henin (1986:339-340) has demonstrated that output diverges from the natural level as a function of unforeseen shocks and non-systematic components of money stock. This means that only unsystematic components of policy can affect output. However, with a supply function of the form of $y_t^s = y_0 + \alpha(P_{t|t-1})$, only the foreseen part of money stock influences output, a violation of the neutrality concept of money (Henin 1986:339-340). Therefore, the analytical results are model specific and sensitive to assumptions about supply function.

2.6 INFLATION DUE TO MONETARY DISCRETION

In the introduction of this thesis, it was pointed out that several studies have shown inflation is costly and if there is no real benefit to having (say) five percent inflation on average, as opposed to one or zero percent, why are average rates of inflation observed that are consistently positive? Several sources of inflation have been discussed but they do not make it explicitly clear why inflation still exists? Literature on time inconsistency[30] by Calvo (1978), Kydland and Prescott (1977), Barro and Gordon (1983), and Barro and Gordon (1983a) amongst others seeks to answer this question. In a discretionary regime, the monetary authority can print more money than expected and create more inflation than people expect. Based on the model of Barro and Gordon (1983a) and the discussion in Walsh (1998:chapter 8) and McCallum (1990), the above point is illustrated below.

While inflation is costly in various ways as discussed in Chapter 1, the benefits from surprise inflation come in at least two ways. One through the Phillips curve, where unanticipated monetary expansion reflected in higher expected inflation leads to an increase in real output. The other source of benefit involves government revenue in the form of seigniorage. The cost of inflation is assumed to rise at an increasing rate with the realized inflation rate, π. The central bank's objective is welfare maximization or a loss (cost net of benefits) minimization problem subject to a set of structural constraints of economy.[31] It is common in monetary economics literature to write the objective function as a loss function for the central bank which needs to be minimized. Thus, the problem can be written as $\min_{i_t} E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L(x_\tau)$, subject to the structural constraint given by $x = F(x,i,z) + e$. Here, $0 \prec \delta \prec 1$ is a discount factor, and x is a vector of endogenous variables, a few of which like output, inflation, interest rate, or the exchange rate may be objectives, which the central bank wants to stabilize around their average values; i is a vector of instruments (generally of size one); z is the vector of non-policy exogenous variables; and e is a vector of stochastic disturbances. The outcome of the

[30] Walsh (1998:321) defines a policy as time-consistent if an action planned at time t for time t+i remains optimal to implement when time t+i actually arrives. If it was not optimal to respond as planned originally then such policy is time-inconsistent.

[31] Such economic analysis is attributed to be initiated in works of Tinbergen (1952) and Theil (1961)

optimization problem is a policy rule $i^* = H(z)$ to be followed by the monetary authorities. Since this rule is obtained as a product of optimization, the parameters of the rule change as and when new information is arrived.

The loss function can be specified in different ways depending upon the motive of the stabilization objectives. However, in order to demonstrate the inflation bias in the simplest possible way a specification similar to Barro and Gordon (1983) is considered here. Let the loss function be linear in output and quadratic in inflation given as below:

$$L(\pi_t, y_t) = \frac{\alpha}{2}(\pi_t - \pi^*)^2 - \beta(y_t - y_t^p) \qquad (2.27)$$

where y^p is potential output π^* is target inflation, which is can be assumed as zero (π^*=0), and $\alpha, \beta > 0$ are the weights given to inflation stabilization and output deviation. Next, consider a Lucas type aggregate supply function

$$y_t - y_t^p = \lambda(\pi_t - \pi_{t|t-1}) + \varepsilon_t \qquad (2.28)$$

and a policy rule, which links inflation (the state variable) with the instrument, the money growth (control variable) as

$$\pi_t = \phi\, \Delta m_t + \upsilon_t \qquad (2.29)$$

where υ is the velocity shock. Now the loss function can be written as $L_t = \frac{\alpha}{2}(\pi_t)^2 - \beta[\lambda(\pi_t - \pi_{t|t-1}) + \varepsilon_t]$, as considered in Barro and Gordon (1983). Plugging the values from (2.28) and (2.29) into (2.27) gives rise to the following loss function.

$$L_t = \frac{1}{2}\alpha(\phi\, \Delta m_t + \upsilon_t)^2 - \beta[\lambda(\phi \Delta m_t + \upsilon_t - \pi_{t|t-1}) + \varepsilon_t] \qquad (2.30)$$

Minimizing with respect to Δm gives the value of money growth as:

$$\Delta m_t * = \beta\lambda / \alpha > 0 \qquad (2.31)$$

Using this value of money-growth the private agent's actual inflation is obtained as $\bar{\pi}_t = \phi\,\beta\lambda / \alpha + \upsilon_t$. With private agents forming their expectation before observing υ_t, the expected average inflation would be $\pi_{t|t-1} = \phi\,\beta\lambda / \alpha$, which is independent of output. The economy suffers from positive inflation without any benefit. The size of the bias increases in the weight put on output β, the responsiveness of output to inflation surprise λ, the responsiveness of inflation to money growth ϕ and decreases in the weight put on inflation α. If the parameter λ is a large positive value, the central bank has incentive to increase inflation. Since private agents know this, the inflation bias goes on increasing without any gains in output at the equilibrium. However, if λ is a very low value, or negative then there is no incentive for the central bank to pursue inflationary policy.

Now, the loss under discretion L_t^d can be calculated as $L_t^d = \frac{1}{2}\alpha(\phi\,\beta\lambda/\alpha + \upsilon_t)^2 - \beta[\lambda(\phi\beta\lambda/\alpha + \upsilon_t - \phi\beta\lambda/\alpha) + \varepsilon_t]$ and the expected loss would be $E[L_t^d] = E[\frac{(\phi\,\beta\lambda)^2}{2\alpha} + \beta\lambda\phi\upsilon_t + \frac{1}{2}(\upsilon_t)^2 - \beta(\lambda\upsilon_t) - \varepsilon_t)]$, which solves to give

$$E[L_t^d] = \frac{(\phi\,\beta\lambda)^2}{2\alpha} + \frac{1}{2}(\sigma_v)^2 \qquad (2.32)$$

Here it is assumed that $E[\upsilon] = E[\varepsilon] = 0$ and σ_υ^2 is the variance of the random inflation control error υ. The expected loss is increasing in the variance of the random control error υ, the weight put on output β, responsiveness of output to inflation surprise λ, responsiveness of inflation to money growth ϕ and decreasing in the weight put on the inflation α.

To contrast the above outcome under discretion with that of a rule consider that the monetary authority is under a contract to set a zero money growth rate, Δm =0. In other words, assuming that parameter ϕ = 0, inflation would be given by $\pi_t = \upsilon_t$. Then, the expected loss under contract $E[L_t^c]$ would be:

$$E[L_t^c] = \frac{1}{2}(\sigma_v)^2 < E[L_t^d] \qquad (2.33)$$

Thus, the point made here is that the loss (or cost) under a rule is lower than that under discretion. The lower cost reflects the value of being able to make a commitment- that is, a contractual agreement between the policymaker and the private agents. Without these commitments, inflation ends up being excessive without benefit.

There are two reasons for inflation bias under discretion. First, the central bank has an incentive to inflate once private-sector expectations are set. Second, the central bank is unable to pre-commit a zero average inflation rate because of optimality condition (2.31), which does not involve any inflation term. Under the rule, if people are expecting zero inflation, then as noted previously, the policymaker would like to implement a positive inflation rate in order to secure some benefits from an inflation shock.

There is a large literature on how to deal with discretion, given the fact that rules are static and central banks should have a dynamic view in policy making. Rogoff (1985) is one of the early analyses in this area to emphasize that the government can achieve better control on inflation by appointing a conservative central banker with a greater disliking for inflation than that of the society as a whole. Some economists, like Minford (1995) and Blinder (1999) consider a public mandate in democratic society can enforce a low-inflation outcome. By setting the goals of central banks quite precisely, discretionary bias can be reduced. Targeting rules, like an inflation targeting rule, under which the central bank is judged on its ability to achieve a pre-specified value for some macro variable, like forecasted inflation, are considered to be potential candidates for reducing inflation bias due to the inherent strength of the operational conditions. An optimal linear inflation target can be implemented if the central bank is required to target a rate that is actually less than the socially optimal rate of inflation (Svensson 1997b). The inflation-targeting rule says "set the instrument such that the conditional inflation forecast hits the inflation target in quarter T" (Svensson 1999). This presumes the central bank has instrument independence and not goal independence. More discussion on regime choice is presented in Chapter 3.

2.7 REAL BUSINESS CYCLE (RBC) MODELS AND INFLATION

The RBC class of models does not recognize the existence of any relationship in the form of the Phillips Curve. Instead the RBC theories claim that observed Phillips-type correlations stem from the monetary system's reaction to output fluctuations that are induced by real shocks to taste or technology – not from the non-bank private sector's reaction to monetary shocks. Thus, 'the distinguishing characteristic of RBC models is denial that monetary policy actions have any significant impact on aggregate output and employment magnitudes' (McCallum 1986). It assumes a perfectly competitive market with prices clearing all the time and that the changes in the real wage of labour, and decisions about labour supply take place in response to technology shocks, and its effect on the real interest rate and other variables.

Thus, the central idea of the theory of real business cycle is based on a constant return to scale production function with a random technology shock λ_t. There is no money in the behavioural system. The household maximizes its utility between expected consumption and leisure subject to their intertemporal budget constraint. Therefore, the labour supply decision is endogenous, which depends upon the interest rate and real wage unlike Keynesian models, where employment is a demand-based phenomenon. Both, a higher relative wage in the current period and a higher interest rate would motivate households to supply more labour during the current period[32]. The implication of the model is a negative relationship between consumption and employment as shown in Romer (1996: chapter 4), a proposition hard to support empirically. The Ricardian equivalence is an essential assumption in order to allow the household to take decisions about current labour supply in view of the government decision to increase its purchases, which would mean an increase in future taxes and hence expected erosion in future household consumption.

Realization of a new value of λ_t for a given labour N_t and capital K_t in time period t results in a new value of output Y_t. In the case of an increased λ_t over its average value, the marginal product of labour, and marginal product of capital, would be higher, as also would capital accumulation. With the increase in the marginal product of labour, the labour demand function in an employment-real wage plane would shift up and to the right. With the labour supply function remaining in

[32] See Romer (1996:156) for analytical derivation. Institutively, a rise in real interest rate increases the attractiveness of working today and saving relative to working tomorrow.

the original position this means a rise in the real wage, higher employment and higher output as a result of both the increase in employment and increase in productivity. However, the wage effect is given little consideration in the quantitative models.

The RBC models are complex for analytical solution due to the inclusion of linear and non-linear functions. Therefore, numerical techniques with assumed parameters have been used in the literature to describe the model properties. Important studies in RBC theory in its quantitative versions include Kydland and Prescott (1982); Campbell (1994); and King, et al. (1991) among others. Romer (1996: chapter 4), based on parameter values from Campbell (1994) has presented several simulated effects of technology shock around a deterministic trend in a standard model. After hitting the economy, by assumption, the technology shock slowly dies down. Capital accumulates gradually and then returns to normal. The labour supply jumps and then declines relatively rapidly, acquiring even negative value before achieving the normal. With the jump in capital accumulation, labour, and technology, the output increases in the period of the shock and then gradually returns to normal. The wage jumps at the time of the shock but subsequently falls very slowly. This leads to the conclusion that, wage plays a minor role in determination of employment. On the other hand, the annual interest rate, after increasing with the technology shock, returns to normal quickly and even dips below the normal. Therefore, it is argued that movement in the interest rate is the primary cause of movements in the labour supply based on households' intertemporal optimization behaviour.

Thus, in RBC framework, the fluctuations in price and inflation are not explicit; these are imbedded in the real quantities. The supply function is mostly dependent upon the evolving real interest rate due to the technology and other shocks hitting the economy. Since it is plausible that changes in technology have a significant permanent component, the RBC models are quite consistent with large permanent output fluctuations. However, Nelson and Plosser (1982) conducted empirical tests to establish that the cyclical components arising out of monetary disturbances contribute little variability to output and employment series in comparison to the fluctuation in the trend component of the variable. McCallum (1986) has criticized their remarks and a wholesome critical discussion of RBC models is presented in Romer (1996:174-189), which includes concerns about the efficacy of technology shock, propagation of the shock through intertemporal substitution in labour supply, omission of monetary disturbances from the model, and critical dependence of the model on a calibration exercise which may not be the unique optimal set. The most serious objection comes from application of the unobservable economy wide technology shock as if that applies to all producers alike. If that is not the case and if random shocks in different sectors are stochastically independent, their effects will tend to average out, yielding a relatively small variance in aggregate. Therefore, it does not provide a convincing way of modeling aggregate supply behaviour in an actual economy (McCallum 1989:195).

2.8 THE STRUCTURAL HYPOTHESIS OF INFLATION

"Structural" models are characterized by the assumption that economic activity can be aggregated into two sectors, a "progressive" (industrial) sector and a "conservative" (service) sector. Given different rates of productivity growth in the industrial and service sector, a uniform rate of growth of money wages throughout an economy must lead to permanent cost pressures in the service sector, which is assumed to have the lower productivity growth. Because firms in this sector use the mark-up pricing rule (a fixed profit margin imposed on rising unit labour costs), this cost pressure creates cost-push inflation for the economy as a whole. Structural inflation, therefore, implies a change in the relative supply price of the two sectors. The supply price of the service sector rises relative to the supply price of the industrial sector. Finally, in simple terms, this type of inflation assumes small price elasticity but a large income elasticity of demand for the output of the service sector (Frisch 1983:153-154). Some of the major contributions in developing this concept include Baumol (1967), Maynard and Ryckeghem (1976), and Aukrust (1977). These works are directed towards explaining inflation in OECD countries. Similar attempts, using the concept of structural inflation, are made to explain inflation in developing countries although with a difference in the emphasis on the sectors.

Kirkpatrick and Nixson (1987) survey the structuralist model of inflation in developing countries. Here, the argument is based on the structural bottlenecks associated with the growth process. The economic, institutional and socio-political structures inhibit economic expansion by not allowing the price mechanism to play its role in the development process. The key bottlenecks generally are taken to be:

the inelastic supply of foodstuffs, foreign exchange constraint and government budget constraints. With a rise of income in the manufacturing sector, the demand for food increases faster than supply in the presence of adverse terms of trade between agriculture and manufacture, shortage of foreign exchange and problems of balance of payments. The result is an increase in food prices, which in turn feeds into the price of manufactures due to wage bargaining and wage indexation in organized sectors. The problems of excess money creation and deficit financing are also considered a major cause of inflation in the developing world. However, causes of money creation may or may not be an error of judgment but certainly could be attributed to structural rigidities and various constraints on growth in the form of a low savings rate, difficulties in financing development projects, underdeveloped financial markets, and the scarcity of private investment capital, to name a few.

From the above discussion, it appears, what structuralists are saying is that monetary growth is in large part endogenous and a response to more fundamental underlying causes of inflation. 'It is extremely important to realize that structuralists do not deny that an inflationary process will require an expansion of the money supply' (Ayre 1981:72).

2.9 INTERNATIONAL TRANSMISSION OF INFLATION

So far, the discussion has been based on a closed economy framework. In an open economy, the economic environment beyond the boundaries of countries, transmitted through the exchange rate route, can also affect both the supply and demand schedules of the home country. In this case, inflation is not only the manifestation of domestic activities but also of the international developments. There can be several interpretations of the international aspects of imported inflation. It can be regarded as an exogenous supply shock in the prices of intermediate goods, or as purely an international monetary phenomenon under the fixed/ flexible exchange rate regime, or a problem of traded and non-traded goods, or " international demonstration effects" or as a combination of different processes (see Laidler and Parkin (1975), for an early survey on inflation). In a world of fixed exchange rates the quantity theory would predict inflation to be a worldwide phenomenon (Laidler and Parkin 1975, Darby and Lotihan 1983). Similar inferences are drawn from discussion of the monetary approach to balance of payments problems (see for example Hallwood and

MacDonald 1995). However, inflation across countries may also vary with a fixed exchange rate, due to the presence of non-traded goods. It is in this context that the following aspects of international inflation are discussed.

Direct Effects of Foreign Inflation

When the economy is involved in trade, domestic prices are directly affected by disturbances taking place abroad and changes in the domestic tariff structure. Simple examples are the setting of oil prices by the oil producing cartel countries and the technology effects on prices of commodities like computer hardware and food products. Several such factors can be considered as exogenous supply shocks. Similarly, variation in commodity prices across countries lead to changes in foreign demand for domestic goods (it could be due to socio-political or other reasons), which in turn may lead to changes in the wage and price setting behaviour of the domestic firms leading to changes in inflation. However, a fall in foreign demand is likely to cause recession in the home country in a complex way.

Inflation as an Exchange Rate Effect

With given world prices and a given price of domestic tradable goods, variations in the exchange rates can affect domestic prices through the prices of tradable goods. Changes in the exchange rate directly affect the domestic currency price of imported final goods, which enter the price index and hence inflation. The other exchange rate channel is where the exchange rate affects the domestic currency price of intermediate inputs. Eventually, it will also affect nominal wages via the effect of the consumer price index on wage setting (like indexation). In both cases, it will affect the cost of domestically produced goods, and hence domestic inflation (Svensson 2000). The real exchange rate affects the relative price between domestic and foreign goods, which in turn, would affect both domestic and foreign demand for domestic goods leading to a variation in inflation.

Inflation from Macroeconomic Interdependence

The Mundell-Fleming model of open economy (Mundell 1963, 1968; Fleming 1962) has been the static work horse of economic literature for demonstrating macroeconomic interdependence, which discusses the transmission of policy stances or economic events from one country to another in a variety of dynamic settings. Another framework that is widely used in the literature of international policy coordination is the two-country model developed in Obstfeld and Rogoff (1995) and

Obstfeld and Rogoff (1996), explicitly based on the assumption of optimizing agents in order to allow the model to address normative policy questions. Utility of the agents depends on consumption, real money holding and leisure implied by disutility of production. Analysis of the basic Obstfeld-Rogoff two-country model under the assumption that prices are set one period in advance generates nominal rigidity leading to real effects of unanticipated monetary disturbances (Obstfeld and Rogoff 1996:chapter 10). Thus, both countries have an incentive to expand money supply leading to biased inflation.

The above approach is also the fundamental basis of modern large scale dynamic general equilibrium macroeconomic models like the McKibbin-Sachs Global (MSG) model, which is contingent upon policy regime choices, model parameters, and forecasting (forward lookingness) of some variables like the exchange rate and degree of international coordination. The dynamic predictions of such models are too complex to be discussed in this chapter. However, for simplicity, and in order to appreciate the international effects, the static results of the policy stances of one country on the inflation of another in a simple Mundell-Fleming two-country model, discussed in McKibbin and Sachs (1991) is represented by equations 2.34 through 2.40 in Table 2.2.

It is assumed that each country produces one good that is an imperfect substitute of the other country's good. Both goods are tradable. The home country and the foreign country have symmetric economies and expectations are static. Deviating from McKibbin and Sachs (1991), the exchange rate is defined here as number of foreign currency per unit of domestic currency. Therefore, appreciation of the domestic currency means a rise in value of the exchange rate and depreciation means a fall in the exchange rate. The goal is to use the model to find a policy multiplier of the sort dX / dY; that is, the change in variable X as a function of a given change in a policy variable Y (Y might be fiscal spending, G, the money supply, M, and so forth).

The consequences of the international transmission of policy under the alternative assumptions about the exchange rate and wage regimes, and the degree of capital mobility are presented in Table 2.3. Studying the results in column p^{c*} provide the effect of the policy action in another country (say country D) on the prices of the country under study (say T).

Table 2.2 A static two-country model

Eqn. No.	Equation	Eqn. No.	Equation
2.34	$m - p = \phi y - \beta i$	2.34*	$m^* - p^* = \phi y^* - \beta i^*$
2.35	$y = -\delta s - \sigma i + \mu g + \gamma y^* - \upsilon t$	2.35*	$y^* = \delta s - \sigma i^* + \mu g^* + \gamma y - \upsilon t^*$
2.36	$p = w + 6 y$	2.36*	$p^* = w^* + \theta y^*$
2.37	$w = \varsigma p^c$	2.37*	$w^* = \varsigma p^{c*}$
2.38	$p^c = \alpha p + (1-\alpha)(-e + p^*)$	2.38*	$p^{c*} = \alpha p^* + (1-\alpha)(e + p)$
2.39	$s = e - p^* + p$	2.40	$i = i^*$

Note: * indicates a foreign country variable. Variable are as follows: y = real output; p^c = consumer price; m= nominal money balance; p= price level; s=real exchange rate; w= nominal wage; i=level of interest rate; e=exchange rate defined as the price of a unit of domestic currency in terms of foreign currency; g= real government expenditure; t=tax rate.

Source: The model is taken from McKibbin and Sachs (1991), Table 2.1. However, the definition of real exchange rate is changed

A monetary expansion in country D would result in a fall in the prices of country T, if country T has regimes of a floating exchange rate with indexed wages, irrespective of the extent of capital mobility. However, if country D also has wage indexation, under perfect capital mobility the price effect on country T would be zero. Under a regime of fixed exchange rate in country T, irrespective of the extent of capital mobility, a monetary expansion in country D would bring about a rise in the prices of country T with wage indexation and will have no effect with a fixed wage.

A fiscal expansion in country D would result in a rise in prices in country T under full capital control if wages in country T are indexed and the exchange rate is fixed and prices would fall under full capital control if the exchange rate is floating irrespective of the wage conditions. Under perfect capital mobility, the prices in country T would rise with a floating exchange rate, while it can go either way with a fixed exchange rate and indexed wages.

Table 2.3 Transmission of policy stance of one country (D, home) on the price in the other country (T, foreign)

Exchange rate and wage regime	Monetary Policy		Fiscal Policy	
	p^c	p^{c*}	p^c	p^{c*}
Perfect capital mobility				
Floating Exchange rate				
Fixed wage	+	-	-	+
Foreign indexation	+	-	±	+
Home indexation	1	0	±	+
Fixed Exchange rate (home peg)				
Fixed wage	0	0	0	0
Foreign indexation	0	0	+	+
Home indexation	0	0	+	+
Fixed Exchange rate (foreign peg)				
Fixed wage	0	0	0	0
Foreign indexation	+	+	±	±
Home indexation	-	+	+	+
Zero capital mobility				
Floating Exchange rate				
Fixed wage	+	-	+	-
Foreign indexation	+	-	+	-
Home indexation	+	-	+	-
Fixed Exchange rate (home peg)				
Fixed wage	0	0	0	0
Foreign indexation	+	+	+	+
Home indexation	+	+	+	+
Fixed Exchange rate (foreign peg)				
Fixed wage	0	0	0	0
Foreign indexation	+	+	+	+
Home indexation	+	+	+	+

Source: McKibbin and Sachs (1991), Table 2.2

International Inflation and Small Open Economy

Two country and multi-country large-scale models provide a useful framework for the analysis of policy interaction in an environment in which development in one economy affects the other. However, for many economies, domestic developments have little or no impact on other economies. Decisions about policy can, in this case, treat foreign interest rates, foreign output levels, and foreign inflation as exogenous because the domestic economy is "small" relative to the rest of the world (Walsh 1998:269). In this case the Phillips curve or the supply equation can be written as a function of unanticipated inflation and the real exchange rate (s), as follows:

$$y_t^{\Delta} = \alpha_s s_t + \alpha_\pi (\pi_t - \pi_{t|t-1}) + \varepsilon_t \tag{2.41}$$

Here y_t^{Δ} is the output gap expressed as the deviation of log output from the log natural rate output ($y_t^{\Delta} = y_t - y_t^{p}$) and as defined earlier, rise in the real exchange rate means currency appreciation.

Defining the output gap as above and taking all variables measured as deviation from the average level (Ball 1998b), used a different lag structure and his supply function gives

$$\pi_t = \pi_{t-1} + \alpha_y y_{t-1}^{\Delta} - \alpha_s (s_{t-1} - s_{t-2}) + \varepsilon_t \tag{2.42}$$

Svensson (1998) using microeconomic foundation as applied in Woodford (1996), and Rotemberg and Woodford (1998), derived the supply function for an open economy as follows:

$$\pi_{t+2} = \alpha_\pi \pi_{t+1} + (1-\alpha_\pi)\pi_{t+3|t} + \alpha_y [y_{t+2|t}^{\Delta} + \beta_y (y_{t+1}^{\Delta} - y_{t+1|t}^{\Delta})] - \alpha_s s_{t+2|t} + \varepsilon_{t+2} \tag{2.43}$$

where again the output gap is defined as above and all other variables are taken as deviations from their constant trend.

It may be noted that all three specification of the supply curve have different underlying assumptions. Equation (2.41) is simply a Lucas type specification with an additional term of real exchange rate. The assumption behind this supply function is that nominal wages are set in advance on the basis of expectations of the price level while actual employment is determined by firms on the basis of realized real wage and therefore on the actual price level. Equation (2.42) is derived as a linear combination of the average inflation of domestically produced goods and imported goods. Domestic goods inflation is given by $\pi_t^{d} = \pi_{t-1} + \alpha_y' y_{t-1}^{\Delta} + \varepsilon_t'$ and the imported inflation by $\pi_t^{m} = \pi_{t-1} - \alpha_s (s_{t-1} - s_{t-2})$. The idea behind this is that the foreign firms desire constant real prices in their home countries, implying that real price in local currency is just the last period's real exchange rate. Therefore, they adjust their prices for any change in the real exchange rate with a period lag. In Svensson's (1998, 2000) supply function of equation 2.43, inflation depends upon the expected future inflation as also the past inflation. The motivation of this model is derived from the consideration that monetary policy must forecast inflation two-periods ahead in order to have two period lags in the effect of monetary policy on inflation.

2.10 CONCLUSIONS AND RELEVANCE TO INDIA

The foregoing discussion supports the point made at the beginning of this chapter, that the debate on the mechanism of inflation is far from settled. This brings to the forefront the importance of country specific empirical studies. However, it can be argued that money growth captures several sources of inflation, including that transmitted from abroad, and inflation can be influenced by controls on money growth. In the economies where the financial market is fully developed, instruments, such as short-term interest rates can find the same role. Nevertheless, wage setting behaviour, supply shocks, and structural rigidities are equally important in modeling inflation. It remains specific to the nature of economy, which model is the most appropriate.

As discussed in Chapter 1 certain specific issues pertaining to the Indian economy relating to the structure of the economy (structural rigidity), administration of some of the prices (government intervention), underdeveloped market clearing aspects of the economy (competitive equilibrium) and the absence of rule based monetary policy (to form rational expectations) make it hard to analyze the determinants of inflation in India using any specific model.

The possibility of supply side inflation accompanied by monetary accommodation is not ruled out. The main sources of supply shocks could be oil prices, currency devaluation, flow of foreign currency, weather conditions affecting agricultural prices, productivity improvements, and price competition together with a changing economic environment due to reforms. In addition, prices of several intermediate and agricultural goods constituting about a quarter of the commodities by weight in the wholesale price index basket of items is administered in one way or the other and public sector wages are indexed to the consumer price index, with a provision of periodic revisions and adjustments. Government interventions in the price setting of administered goods and lump sum increases in wages arising out of periodic adjustment also contribute to supply side effects on inflation.

Finally, in the absence of transparency and the desire to stimulate the economy to a higher growth path, monetary authorities can always generate inflation of the type of discretionary policy, though this may be with ad hoc decisions instead of model optimization.

Annexure 2.1:
A brief note on 'Six Equations Keynesian Model'

Let capital K, and labour N be used to produce output Y per period, which is divided among real rate of consumption C, real rate of investment I, real rate of government purchases G, and real rate of depreciation of capital δK. Let π^e be anticipated inflation, i the instantaneous rate on government bonds, δ the instantaneous rate of physical depreciation such that the appropriate cost of capital is $i-\pi^e+\delta$. Let P be the price of the unit good, W the money wage of unit labour; let q be Tobin's q and refers to the relative price[33] that governs firms' demand to accumulate capital; and let wealth of the household be divided between money balance M, bonds B and value of the firms V. The six equations describing the Keynesian Model can be written as follows:

$$Y = F(K,N) \tag{A2.1}$$
$$W/P = F_N \tag{A2.2}$$
$$C = C(Y - T - \delta\, K - \frac{M+B}{p}\pi, i-\pi) \tag{A2.3}$$
$$I = I\ (q(K,N,\delta, i-\pi)-1) \tag{A2.4}$$
$$Y = C + I + G + \delta\ K) \tag{A2.5}$$
$$\frac{M}{P} = m(i,Y) \tag{A2.6}$$

The important assumptions with the model are: F_N, F_K>0; F_{KK}, F_{NN}<0; m_i<0; m_y>0; 1>C_1>0; C_2<0; I'>0; $q_{i=\pi^e}$<0. The model differs from the classical paradigm, which includes two more equations to describe the labour market equilibrium. Labour supply $N^S = N^S(W/P)$ and $N = N^S$ which results in $N = N^S(W/P)$, such that the nominal wage is determined endogenously. The labour market in a Keynesian framework can be incorporated while keeping the money wage exogenous through a seventh equation of the type $N^S = N^S(W/P)$ and $N < N^S$, lying outside the above system ensuring an excess supply of labour with respect to the demand given by equation (A2.2).

[33] $q = \frac{F_K - (i+\delta-\pi^e)}{i-\pi^e} + 1 \equiv q(K,N,i-\pi^e,\delta)$ and $I = I(\frac{F_K - (i+\delta-\pi^e)}{i-\pi^e}) = I(q-1)$

The system of the above six equations can be totally differentiated and solved to get the standard IS[34] and LM[35] curves representing equilibrium in goods markets and money markets. General equilibrium in the money market and goods market determines output, which in turn determines labour demand N with real wages equalized to the marginal product of labour. Since the money wage is exogenous, the price level is determined by taking the ratio of money wage to the real wage. An increase in the money wage will amount to an increase in the price level for a given level of output. That disturbs equilibrium in the money market because it reduces real balance, forcing households to sell bonds to meet the excess demand for money. The interest rate rises, restricting investment and consumption, causing aggregate demand to fall short of aggregate supply, forcing the prices to fall back. This fall in price affects the labour market increasing real wages, and reducing employment and output until a new equilibrium is arrived at a higher interest rate and lower output. This has the same effect as shifting the LM curve to the left.

The general equilibrium of the above system in the short run ($dK = 0$) can also be represented in the price output plane. Solving the totally differentiated equations (A2.1) and (A2.2) yields the aggregate supply schedule, and solving the totally differentiated equations (A2.3) to (A2.6) yields the aggregate demand schedule:

Aggregate supply

$$dY = \frac{F_N^2}{F_{NN}}\frac{dW}{W} - \frac{F_N^2}{F_{NN}}\frac{dP}{P} \qquad \text{(A2.7)}$$

[34] The name IS comes from the fact that in a closed economy, the condition that the quantity produced is equal to quantity demanded is equivalent to the condition that planned investment is equal to savings. The IS curve is down-ward sloping in the output-real interest rate plane because a higher interest rate reduces investment demand, reduces demand for consumer durables and, with a floating exchange rate, bids up the value of domestic currency and thereby reduces net export. Demand for output falls when the interest rate rises.

[35] The name LM comes from the relationship between liquidity preference and money supply, which determines the equilibrium nominal interest rate in the money market. If the money supply is fixed by the central bank, a rise in aggregate income, by raising the demand for excess liquidity, raises the interest rate at which the money market clears.

Aggregate demand

$$dY\,(1 - C_1 - I'\frac{q_N}{F_N} + \frac{C_2 + I'q_{i-\pi^e}}{m_i}m_y) \tag{A2.8}$$

$$= -\,C_1 dT + dG - (C_2 + I'q_{i-\pi^e})d\pi^e + \frac{(C_2 + I'q_{i-\pi^e})}{m_i}\frac{dM}{P}$$

$$-\frac{(C_2 + I'q_{i-\pi^e})}{m_i}\frac{M}{P^2}dP$$

With the assumption of F_N, F_K >0; F_{KK}, F_{NN} <0; m_i <0; m_y >0; 1> C_1 >0; C_2 <0; I' >0; $q_{i=\pi^e}$ <0, stated earlier, it can be shown that the supply curve is upward sloping and the demand curve is downward sloping in the output price plane as shown in Figures 2.1 and 2.2.

Chapter 3

The Theory of Monetary Regime Design

3.1 INTRODUCTION

A monetary policy regime is concerned with the choice of instruments, operating targets and intermediate targets, with the objective of meeting ultimate policy goals. This process results in a systematic rule (either simple or very complex) for adjusting the instrument (quantity or price) in response to new information. Goal variables are the ultimate variables of interest to policymakers and typically include inflation, real output or unemployment. However, the consensus that monetary policy is neutral in the long run restricts the set of feasible long-run goal variables for monetary policy, in that case inflation remains the most plausible long-term goal variable. Intermediate targets include exchange rates, broader monetary aggregates, nominal output, and more recently inflation forecasts. Operating targets could be bank reserves or overnight inter-bank short-term rates (like call money rates).

The instruments are the variables which the central bank finds in its direct control and which are easily manipulated to achieve a desired value for the operating and intermediate targets. Instruments include interest rates on borrowings from the central bank (interest rate on reserve money like overnight rates, 'repo'[36] rates or 90 days bill rates) or a reserve requirement ratio (like cash reserve ratio, CRR) or central banks' holding of government securities (treasury bills, TB). The problem facing the monetary authorities is to choose an appropriate instrument and intermediate target/targets, and a rule defining their interrelationship. This is what constitutes the regime of monetary policy. The problem that arises is which regime performs better in a given economic environment? Many answers are theoretically ambiguous and

[36] Repurchase agreement of government securities

thus the ultimate answer is to be found by empirical analysis of the regimes in simpler models like that demonstrated in de Brouwer and O'Regan (1997), Cecchetti (1998), Svensson (2000) among others or global models like McKibbin-Sachs Global (MSG2) model.[37] These models are used to generate profiles of inflation and output variability that can be compared across regimes. For a current discussion on performance of different monetary policy regimes reference can also be made to Mishkin (1999) and McCallum (1999) among others.

At this stage it is natural to ask, why should the central bank follow rules at all? This question has been discussed in the literature on the discretion vs. rule debate. Cecchetti (1998) gives two important reasons to support the adoption of rules. The first is the now established finding that when policymaking is based on pure discretion rather than rules, dynamic inconsistency can lead to high steady state inflation due to an inflation bias (see discussion in Chapter 2 and also Walsh 1998:321-335). The second reason concerns the importance of policy transparency, which makes the central bank accountable for whatever target it fixes, and the way the central bank carries out its policies. Such arguments have found favour in a number of countries like Australia, Canada, New Zealand, Spain, the United Kingdom, Sweden, and Israel to implement explicit targeting regimes.

There are several approaches followed in the literature on implementing monetary regimes. In the remainder of this chapter the discussion on theory behind some of the popular instruments, targets, rules and the monetary policy regime is organized as follows. The instrument choice problem is discussed in section 3.2. Section 3.3 discusses the intermediate target problem. Some of the common rules discussed in the literature are presented in section 3.4. Section 3.5 discusses common regimes of monetary policy and the strategies of inflation control in different regimes. Since several countries have adopted an inflation targeting regime and the RBI is also considering this option, a brief discussion on inflation targeting is presented in section 3.6. The concluding remarks are presented in section 3.7.

[37]See for example Bryant, et al. (1993); McKibbin (1993), Henderson and McKibbin (1993); Henderson and McKibbin (1993a); McKibbin (1997); McKibbin, et al. (1998).

3.2 THE INSTRUMENT CHOICE PROBLEM

Traditionally, central banks work through a fractional reserve banking system where the two most common modes of operations are legislative controls and open market operations. In several economies the central bank holds the power to specify CRR requirements within legislatively specified limits, which allows it to have direct quantitative control on the monetary aggregates. In open market operations the central bank buys or sells government securities to influence the operating targets. With the interest rate as the main operating instrument, it is also effective to work through an announcement effect, where the central bank sends signals about the desired market rates by announcing the bank rates and the market often responds quickly to such announcements.

The central bank has the choice to use either quantity or price of the securities as the instrument. Since the price of the security is inversely related to the interest rate and changes in the stock of securities determines the changes in the reserve money and hence monetary aggregates, the eventual decision is to choose between monetary aggregate and the interest rate as the instrument. The classic analysis of this question is due to Poole (1970) which has since been extended in a number of other studies and has been useful in a variety of settings even beyond monetary policy issues like fixed versus flexible exchange rate and nominal versus indexing of wages[38]. Following Poole (1970), Friedman (1990) and Walsh (1998), Poole's approach can be illustrated in a simplified version as follows.

Choice Between Money and Interest Rate

Let the following equation represent the basic static stochastic IS-LM model in log terms with constant price $p = 1$. Let Y_t, M_t, and R_t be output, money and interest rate at any time t, and Y_t^P, $\overline{M}_t$, $\overline{R}_t$ be their trend (or equilibrium) values then these variables can be defined in terms of deviations from the trend as $y_t^\Delta = \log(Y_t / Y_t^P)$, $m_t^\Delta = \log(M_t / \overline{M}_t)$, $i_t^\Delta = \log(R_t / \overline{R}_t)$, with $E[y] = 0$, $E[m] = 0$, $E[i] = 0$, where 'E' is an expectation operator.

$$y_t^\Delta = -\alpha_i i_t^\Delta + u_t \tag{3.1}$$

$$m_t^\Delta = \beta_y y_t^\Delta - \beta_i i_t^\Delta + v_t \tag{3.2}$$

[38] For example see Roper and Turnovsky (1980), Aizenman and Frenkel (1985), Fischer (1977a), Gray (1976)

Equation (3.1) represents an aggregate-demand relationship in which y_t^Δ is the measure of output gap from the equilibrium (or trend), i_t^Δ is deviation in interest rate from its trend, α is positive coefficient and u_t is an exogenous disturbance. Similarly the money demand (equation 3.2) is an increasing function of output and decreasing function of interest rate and is also dependent upon a random shock v_t; β_i and β_y are positive constants. At equilibrium money demand equals money supply. Let, $E[u]=E[v]=0$, $E[u^2]=\sigma_u^2$, $E[v^2]=\sigma_v^2$, $E[uv]=\sigma_{uv}=\rho_{uv}\sigma_u\sigma_v$. Poole assumes a quadratic loss function for the central bank, which gives the expected loss function as $L=E[y_t^\Delta]^2$. The objective is to minimize the variance of output deviation given by the loss function. With the above assumptions the equilibrium level of output gap in absence of shocks is zero and therefore, the objective is:

$$\text{Minimize } E[y_t^\Delta]^2 \tag{3.3}$$

The two policy instruments, money and interest rate will give two different values of the above loss function and choice for the instrument will rest on the one, which gives minimum loss between the two.

If the policy instrument is money, the central bank sets $m^\Delta=0$, such that $E[y^\Delta]=0$ (from (3.2)), at the start of the period; then shock u occurs which determines the values of endogenous variables y^Δ and i^Δ. For the equilibrium conditions these can be jointly determined from (3.1) and (3.2). The value of y^Δ can be written as follows.

$$y_t^\Delta = \frac{\alpha_i m_t^\Delta + \beta_i u_t - \alpha_i v_t}{\beta_i + \alpha_i \beta_y} = \frac{\beta_i u_t - \alpha_i v_t}{\beta_i + \alpha_i \beta_y} \tag{3.4}$$

Putting this value in (3.3) the value of loss function can be written as

$$E_m[y_t^\Delta]^2 = \frac{\beta_i^2\sigma_u^2 + \alpha_i^2\ \sigma_v^2 - 2\alpha_i\beta_i\sigma_{uv}}{(\beta_i + \alpha_i\beta_y)^2} \tag{3.5}$$

If the policy instrument is interest rate, the central bank sets $i^\Delta = 0$ such that (from (1)) $E[y^\Delta] = 0$, at the start of the period; then shock v occurs in the money market, which determines the values of endogenous variables y^Δ and m^Δ. For the equilibrium conditions these can again be jointly determined from (3.1) and (3.2). The value of y^Δ can be written as:

$$y_t^\Delta = -\alpha_i i_t^\Delta + u_t = u_t \tag{3.6}$$

Now the value of the loss function is

$$E_i[y_t^\Delta]^2 = \sigma_u^2 \tag{3.7}$$

Comparing equation (3.5) and (3.7) can evaluate which policy gives lower variance in the output. The money stock policy is preferred to interest-rate policy if

$$E_i[y_t^\Delta]^2 = \sigma_u^2 > E_m[y_t^\Delta]^2 = \frac{\beta_i^2\sigma_u^2 + \alpha_i{}^2\sigma_v^2 - 2\alpha_i\beta_i\sigma_{uv}}{(\beta_i + \alpha_i\beta_y)^2} \tag{3.8}$$

This condition can be more usefully written as

$$\begin{aligned} 1 &> (\beta_i + \alpha_i\beta_y)^{-2}\left(\beta_i^2 + \alpha_i{}^2\frac{\sigma_v^2}{\sigma_u^2} - 2\alpha_i\beta_i\frac{\sigma_v}{\sigma_u}\rho_{uv}\right) \\ &= (\beta_i + \alpha_i\beta_y)^{-2}\left[\left(\alpha_i\frac{\sigma_v}{\sigma_u} + \beta_i\right)^2 - 2\alpha_i\beta_i\frac{\sigma_v}{\sigma_u}(1 + \rho_{uv})\right] \end{aligned} \tag{3.9}$$

Which is < $(\beta_i + \alpha_i\beta_y)^{-2}\left(\alpha_i\frac{\sigma_v}{\sigma_u} + \beta_i\right)^2$ and $\Rightarrow 1 > (\beta_i + \alpha_i\beta_y)^{-2}\left(\alpha_i\frac{\sigma_v}{\sigma_u} + \beta_i\right)^2$ is feasible condition for money stock policy to be preferred.

Equation (3.9) means that feasibility condition for money stock policy to be preferred can be satisfied if $\frac{\sigma_v}{\sigma_u} < \beta_y$. Thus, money stock policy would be preferred if aggregate demand shock and/or income elasticity of money is large. It can be easily shown diagrammatically that the possibility of this condition to be satisfied considerably depends on the structural parameters (slope coefficients) of the system and money stock policy would be preferred if the LM curve is flat (low β_i / β_y) or the IS curve is steep (small α_i).

With the interest rate as policy (equation-3.7), money is elastically supplied and therefore income is a shield from any shock affecting portfolio behaviour but there is no protection from the disturbances to spending behaviour. On the other hand, if money stock is fixed the interest rate fluctuates so as to damp the impact of disturbance to spending while income is exposed to disturbances in portfolio behaviour. Thus, if only demand shocks are present in the economy (σ_v^2=0), a money stock policy would lead to smaller variance in output. Under the money stock policy a positive IS shock leads to an increase in the interest rate, which acts to reduce aggregate spending, thereby partially offsetting the original shock. If only money demand shocks are present, (σ_u^2=0), output could be stabilized perfectly under an interest rate policy while under a money stock policy money demand shock causes the interest rate to move to maintain money market equilibrium which in turn leads to output fluctuations.

With both types of shocks, which instrument is preferable is an empirical question. It depends on the values of the two variances (σ_u^2 and σ_v^2) and covariance as well as the behavioural parameters of the model.

Choice Between Base Money and Interest Rate: Effect of Multiplier

One of the problems with broader money as instrument is that it limits the capability of the central bank to set money stock exogenously. To solve this problem it is suggested in the literature to derive money demand as a measure of indirect liability. In that case, the instrument problem reduces to a choice between base money and interest rate. Following Modigliani, et al. (1970) and Walsh (1998) the base money and the money supply can be linked by an equation like:

$$m_t^{\Delta} = b_t^{\Delta} + hi_t^{\Delta} + \omega_t \qquad (3.10)$$

Where b^{Δ} is the deviation of base money defined in the same way as m^{Δ}, and ϖ can be interpreted as the money multiplier shock. Now, it can be seen that while interest rate policy is still not affected, the base money policy would give a different expression for output and output variance as stated below:

$$y_t^{\Delta} = \frac{(\beta_i + h)u_t + \alpha_i \varpi_t - \alpha_i v_t}{\beta_i + h + \alpha_i \beta_y} \quad (3.11)$$

$$E_b\left[y_t^{\Delta}\right]^2 = \frac{(\beta_i + h)^2 \sigma_u^2 + \alpha_i^2(\sigma_\varpi^2 + \sigma_v^2 - 2\sigma_{\varpi v}) + 2(\beta_i + h)\alpha_i(\sigma_{u\varpi} - \sigma_{uv})}{(\beta_i + h + \alpha_i \beta_y)^2} \quad (3.12)$$

The base money policy would be preferred only if $E_b\left[y_t^{\Delta}\right]^2 < E_i\left[y_t^{\Delta}\right]^2 = \sigma_u^2$. But an inspection of equations (3.12) and (3.5) indicates that $E_b\left[y_t^{\Delta}\right]^2 > E_m\left[y_t^{\Delta}\right]^2$ for $\sigma_{uv} = \sigma_{u\varpi} = \sigma_{v\varpi} = 0$, due to the presence of money multiplier disturbances (σ_ϖ^2). This makes interest rate policy desirable over money stock policy if financial volatility increases (large σ_ϖ^2) or money demand become highly unstable (large σ_v^2) and difficult to predict over a short period of horizon. In such situation, interest rate policy can have a better stabilizing effect and money stock could be left to fluctuate. However, if the main source of instability arises from aggregate spending then money stock policy would provide more stability. And if the income elasticity of money is very low or is not significantly different than zero, then interest rate policy should again be preferred.

The choice of instrument variable is an endogenous decision and would become more complicated when more than one variable is included in the objective loss function of the bank. For example, the policy makers may be interested in minimizing the variance of output as well as inflation with some weights assigned to them. Similarly, expectations and supply disturbances can also be included in the model. A survey of several supply-demand models, including neutrality and non-neutrality of monetary policy presented in Friedman (1990), indicates that the choice of instrument may not be model invariant.

Specific mention can be made of the problem of price level indeterminacy obtained by Sargent and Wallace (1975) due to their rationality assumption in the model, which led them to conclude the interest rate instrument was not only inferior but also implausible on an a priori basis. This led to the notion that only money could be the instrument until McCallum (1981) demonstrated that this indeterminacy of price under interest rate instrument would follow only in the case in which the central bank's policy rule placed no weight on price (case of "pure interest rate peg" where money is entirely disregarded). McCallum showed that as long as some weight is placed on price in the policy rule function of the central bank determinacy would prevail. A similar outcome has been demonstrated in Henderson and McKibbin (1993a). In addition, the role of nominal anchor has also been emphasized in the literature (see Barro and Gordon (1983); Kydland and Prescott (1977); Mishkin (1999)) on other grounds, particularly as a constraint on the discretionary policy that helps in reducing the time-inconsistency problem (also see discussions in Chapter 2).

Combination Instrument Policy

Poole's basic model is based on the assumption that the interest rate could be observed while current values of output and underlying disturbances could not be observed. In case the money stock, income and the interest rate are continuously observed, then neither a monetary instrument nor an interest-rate instrument would be optimal. The ideal policy could then be a combination policy that permits both money supply and interest rate to change in response to disturbances and it may be pragmatic to supply money according to a more general relationship. With three possible instruments the base money b, the money supply m and the interest rate, a general policy rule can be written (with constants normalized to zero) in the following form representing how base money is varied by the central bank in response to interest rate variation (Walsh 1998).

$$b_t^{\Delta} = \mu i_t^{\Delta} \tag{3.13}$$

Here $\mu \to \infty$ means an interest rate rule $\mu = 0$ means base money rule and $\mu = -h$ means money supply rule.

Solving (3.1), (3,2), and (3.10) yield the following:

$$i_t^{\Delta} = \frac{v_t - \varpi_t + u_t \beta_y}{\beta_y \alpha_i + \beta_i + \mu + h} \tag{3.14}$$

$$y_t^{\Delta} = \frac{(\beta_i + \mu + h)u_t - \alpha_i (v_t - \varpi_t)}{\beta_y \alpha_i + \beta_i + \mu + h} \tag{3.15}$$

$$\sigma_y^2 = \frac{(\beta_i + \mu + h)^2 \sigma_u^2 + \alpha_i^2 (\sigma_v^2 + \sigma_\varpi^2)}{(\alpha_i \beta_y + \beta_i + \mu + h)^2} \tag{3.16}$$

For the sake of simplicity and clarity of exposition, equation (3.16) is simplified by assuming $\sigma_{uv} = \sigma_{u\varpi} = \sigma_{v\varpi} = 0$.

Minimize the variance given by equation (3.16) with respect to μ, the optimal value of the policy parameter is obtained as:

$$\mu^* = -(\beta_i + h) + \frac{\alpha_i(\sigma_v^2 + \sigma_\varpi^2)}{\beta_y \sigma_u^2} \tag{3.17}$$

Thus, none of the above policy is optimal. Instead, the policy response to interest rate changes will depend on the relative variances of the underlying economic disturbances. In the model it is assumed that the current value of the output and the underlying disturbances could not be observed. But suppose that the shocks u, v and ϖ are observed and the central bank can respond to them by using a rule of the form $b_t^\Delta = \mu_u u_t + \mu_v v_t + \mu_\varpi \varpi_t$ where μ_u, μ_v and μ_ϖ are parameters. With this rule, (3.1) (3.2), and (3.10) can be solved to get $y_t^\Delta = \frac{(\beta_i + h + \alpha_i \mu_u)u_t - \alpha_i(1 - \mu_v)v_t + \alpha_i(1 + \mu_\varpi)\varpi_t}{\beta_y \alpha_i + \beta_i + h}$. In this case, now it can be seen that the variance in output is minimized if μ_u, μ_ϖ and μ_v are selected such that $\mu_u = -(\beta_i + h)/\alpha_i$, $\mu_\varpi = -1$ and $\mu_v = 1$.

With these as the expected values of the parameters and forecast of the disturbances $\hat{u}$, $\hat{v}$ and $\hat{\varpi}$ the linear policy structure can be written as:

$$b_t^\Delta = -(\frac{\beta_i + h}{\alpha_i})\hat{u}_t + \hat{v}_t - \hat{\varpi}_t = \left(-(\frac{\beta_i + h}{\alpha_i})\hat{\delta}_u + \hat{\delta}_v - \hat{\delta}_\varpi \right) i_t^\Delta \equiv \mu^* i_t^\Delta \tag{3.18}$$

Here $\hat{u}_t = \hat{\delta}_u i_t^\Delta$, $\hat{v}_t = \hat{\delta}_v i_t^\Delta$, $\hat{\varpi}_t = \hat{\delta}_\varpi i_t^\Delta$ and it is assumed that the forecasts of disturbances depend on the interest rate. If it were the case that the forecast of underlying disturbances are based on the observed interest rate then the optimal policy response can be said to represent an optimal response to the central bank's forecasts of the underlying disturbances. However, in a more general setting the underlying disturbances may also depend on other variables such as the exchange rate, and assets and commodity prices.

Now suppose the interest rate is observed continuously but money stock is known with a one-month lag and income with a quarter lag. Then the combination of policy cannot be followed because it is impossible to maintain a fixed relationship between money and interest rate. Friedman (1977) suggested controlling the policy interest rate and changing that rate in response to the monthly observations of the money stock as a feasible alternative. From the literature and the practices of central banking it appears in general that the modern central banks predominantly use interest rate as the key policy instrument.

3.3 INTERMEDIATE TARGET PROBLEM AND GOAL VARIABLES

Conventionally, central banks appear to use some kind of intermediate target for conducting monetary policy. The main idea behind using an intermediate target is the fact that these variables are more up-to-date in information content than the ultimate target variables. The selected instrument, whether an interest rate or non-borrowed reserves or base money itself and the intermediate target, together form a policy rule in a form that the intermediate target could be systematically influenced by the instrument variables. As noted by Svensson (1997:1126), an ideal intermediate target 'is highly correlated with the goal, easier to control than the goal, easier to observe by both the central bank and the public than the goal, and transparent so that central bank communication with the public and public understanding and public prediction of the monetary policy are facilitated'. Observations for such variables are available on a more timely and continuous basis than the ultimate target variables like output and general prices. The intermediate target variables are in fact endogenous variables determined by the models.

In conventional monetary targeting, the growth rate of monetary aggregate takes the role of intermediate target but any other endogenous variable can also provide useful information and thus be used as an intermediate target. The important point here is that under a dynamic setting the value of the intermediate target can be observed before some policy decision or adjustment to earlier policy decision is made but the values of the goal variables cannot be observed at the same time. However, deviation in the intermediate target from its expected path indicates likely deviation of a goal variable from its target and thus provides a signal to adjust the instrument and the operating target variable accordingly. This requires a very tight relationship between the goal variable and the intermediate target.

The information contained in the intermediate target variable can be used in two ways. One is to choose the instrument setting in such a way that the expected deviation in the intermediate target variable from its target be minimized. The second is to use the information to derive an optimal feedback rule by relating the value of the policy instrument to the observed value of the information variable. Under the optimal feedback rule, the information in the intermediate target is used to choose the value of the policy variable that minimizes the loss function itself. Thus the stress here is to minimize the expected deviation of the goal variable from its target instead of minimizing the expected deviation of the intermediate target variable from its target. This kind of use of the information variable dates back to Kareken, et al. (1973). Friedman (1975, 1977) demonstrated that intermediate targeting is inefficient compared to the optimal feedback rule, with both an interest rate as the instrument or reserves as the instrument. Rules obtained in the case of the former did not minimize the variance in the output when compared to the later. Walsh (1998) draws a similar conclusion where the objective function is to minimize expected squared deviations of the inflation rate around a target level. It is shown that the optimal feedback rule out-performs intermediate money targeting, however an intermediate target does better than a policy which does not respond to new information so long as money-demand shocks are small.

Besides growth of broader aggregates of money, the nominal exchange rate has also been used as an intermediate target, particularly as a means to control inflation. As mentioned in Chapter 1, with the breakdown of the relationship between monetary aggregates and goal variables, such as inflation and output, several countries have recently adopted inflation itself as the target, where forecasted inflation is promoted as a potential intermediate target. In the case of an inflation forecast as the intermediate target, Svensson (1997) claims it to be an ideal intermediate target as it is by definition the current variable that is most correlated with the goal. The choice of inflation as the main goal variable is also prompted from the consensus that monetary policy is neutral in the long run, which restricts the set of feasible long-run goal variables for monetary policy, nevertheless, inflation is not the only possibility.

A number of economists such as Bean (1983), Taylor (1985), Hall and Mankiw (1994), McCallum (1997b), McCallum and Nelson (1999) have advocated nominal income as an alternative intermediate target.[39] Nominal GDP growth, which can be thought of as "velocity corrected" money growth (that is, if velocity were constant, nominal GDP growth and money growth would be equal, by definition), has the advantage that it does put some weight on output as well as prices. Under a nominal GDP target, a decline in projected real output growth would tend to be stabilizing. However, as a matter of revealed preference, in recent years, several countries that have adopted explicit policy framework, virtually all have opted for targets expressed in terms of inflation rates, not money stock or nominal income growth rate (McCallum 1999, Bernanke and Mishkin 1997).

There are two major practical disadvantages with the nominal GDP target compared to inflation as target. First, information on prices is timelier and more frequently received than on nominal GDP, which requires collection of data on both current quantities as well as current prices. Second, the public can more easily understand the concept of an inflation target than the concept of nominal income targeting and therefore inflation targeting better serves the objectives of communication and transparency.

In addition, nominal income targeting is not free from theoretical criticism. As can be inferred from the studies of Bean (1983) and West (1986), alternative choices of supply functions give rise to entirely opposite results between choosing nominal income or monetary aggregate as a policy target.[40] With a backward-looking supply function, Ball (1997) has shown nominal income targeting as an unstable proposition (also see de Brouwer and O'Regan 1997). Therefore, the results of nominal income targeting are also not model invariant. Further, Hall and Mankiw (1994) point out that the equal weighting of real output growth and inflation implied by nominal GDP

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39 Other early works advocating nominal income targeting include Meade (1978), Tobin (1980), Brittan (1981)

40 In his study on a comparison of nominal income targeting with money supply targeting, Bean (1983) used a rational expectation model and measured the desirability of policies by their effect on variance of output around a certain full information level and concluded that monetary policy based on nominal income as an intermediate target is likely to be preferable to a policy based on exogenously determined money provided elasticity of aggregate demand with respect to real balances is less than one. On the contrary, West (1986), showed that, if the objective of monetary policy is to minimize the unconditional variance of output, nominal income targeting can be preferred to fixed money stock if, and only if, the elasticity of aggregate demand with respect to real balances is greater than one, a completely opposite result to Bean (1983).

targeting is not necessarily optimal and, in general, the relative weight put on the two goal variables should reflect social preferences.

3.4 REPRESENTATION OF REGIMES BY SIMPLE RULES

As discussed above, calculating an optimal feedback rule requires a complex process of constrained optimization in which the policy instrument is supposed to respond to a range of information in a given time period. In practical models there could be vector of targets or goal variables, a vector of predetermined state variables, a vector of forward looking variables and a vector of innovations to the state variables. This brings about uncertainty about the true model and complicates the derivation of the optimal feedback rule. McKibbin (1997) points out that it is difficult to distinguish between discretion and a complex rule and advocates the use of simple rules as an alternative. At the same time it is cautioned that such rules must be robust to different models of the economy in addition to the model in which that was developed. These range from simple ad hoc rules to analytically derived optimal feedback rules such as the nominal money rule, 'Taylor rules' (Taylor 1993), 'CC rule' (Henderson and McKibbin 1993), 'nominal-income targeting rules' (McCallum 1989), and 'inflation forecast targeting rule' (Svensson 1997, 1999). Some of the popular interest rate rules are presented in Table-3.1.

Table 3.1 Alternative interest rate instrument rules

1.	Money Rule	$i_t = \bar{i}_t + \beta(m - \bar{m}_t)$	(3.19)
2.	Nominal-Income Rule	$i_t = \bar{i}_t + \beta(p_t + y_t - \overline{p_t + y_t})$	(3.20)
3.	Bryant-Hooper-Mann Rules		
3a.	Henderson-McKibbin (or CC) Rule	$i_t = \bar{i}_t + \alpha(\pi_t + y_t - \overline{\pi_t + y_t})$	(3.21)
3b.	Taylor Rule	$i_t = \bar{r}_t + \pi_t + 0.5(\pi_t - \bar{\pi}_t) + 0.5(y_t - \bar{y}_t)$	(3.22)
4.	Inflation-only rule	$i_t = \bar{r}_t + \pi_t + \gamma_1(\pi_t - \bar{\pi}_t)$	(3.23)
5.	Change rule	$i_t = \bar{i}_t + \pi_t + \gamma_1(\pi_t - \bar{\pi}_t) + \gamma_2(y_t - \bar{y}_t)$	(3.24)
6.	Constant-real-interest rate rule	$i_t = c + \pi_t$	(3.25)

Where: i = nominal interest rate; r = real interest rate; π = inflation rate; p = log of price level; y = log of output; m = log of money and; c = constant; a bar over a variable indicates a desired value

Sources: McKibbin (1997); de Brouwer and O'Regan (1997)

The importance of looking into the future has been realized in several economies where central banks interpret current economic and financial market data with an eye to anticipating future inflationary forces in order to counter them by taking advance action. In recent years, monetary policy in G7 countries has been driven more by anticipated future rather than lagged actual outcome (Clarida, et al. 1998). The forward-looking behaviour in policy rules is incorporated such that the rule feed back from expected value of future inflation. A generic form of such a forecast- based rule discussed in Batini and Haldane (1998) can look like:

$$r_t = \gamma r_{t-1} + (1-\gamma)r_t^* + \theta(\pi_{t+j|t} - \pi^*) \tag{3.26}$$

where $r_t \equiv i_t - \pi_{t+1|t}$, i is nominal interest rate, γ, θ and j represent degree of interest rate smoothing, policy feedback parameter and targeting horizon respectively. According to this rule, monetary authorities control deterministically the nominal interest rate so as to hit a path for the short-run real interest rate. Forward looking policy rules can also be derived analytically by including forward looking variables into the model or incorporating forward looking demand and supply schedules into the model[41].

3.5 ALTERNATIVE POLICY REGIMES AND STRATEGIES OF INFLATION CONTROL

From the foregoing discussion, it is clear there are two central characteristics of regime design that can differentiate between the regimes. These are: (1) policy structure of the regime, which indicates the extent of the systematic component of the operating procedure of the monetary policy and (2) the policy mode of the regime, which indicates the degree of discretion applied in conducting the monetary policy. An approximate classification of the monetary policy regimes based on the above two characteristics is presented in Table 3.2, which is based on the discussion provided in Lindsey (1986) and Masson, et al. (1997). The arrows in the two

[41] Forward-looking behaviour can be incorporated in Phillips curve (see discussions in Chapter 2 and also Roberts (1995)). Woodford (1996) and McCallum and Nelson (1997) use aggregate demand curve consistent with intertemporal optimization which can be reduced to incorporate forward looking behaviour.

columns below the 'type of policy mode' indicate the extent of discretionary and non-discretionary nature of the policy mode.

Among the several possibilities emanating from the above imprecise matrix of regimes the popular literature[42] focuses on three basic strategies for achieving price stability, which are: (i) exchange rate pegging with a large low inflation country; (ii) monetary targeting; and (iii) inflation targeting. Some countries follow a mix of strategies.

Table 3.2 Alternative monetary policy regimes

Type of Policy Structure	Type of Policy Mode	
	← Non-discretionary	Discretionary →
(1) Simple Rules without feedback	**A** e.g. Currency board, Fixed Exchange Rate Targeting	**B** e.g. Once for all devaluation or change in money growth rule from k percent to k+x percent
(2) Simple feedback Rules	**C** e.g. money rules provided in Table 2.1	
(3) Intermediate non-monetary targeting with feedback		**D** e.g. nominal income targeting
(4) Intermediate monetary targeting with feedback	**E** e.g. Bundesbank type monetary targeting	
(5) Ultimate targeting with continuous feedback to instruments		**IT** (Inflation targeting)

Sources: Based on Masson, Savastano and Sharma (1997), Lindsey (1986)

Exchange rate pegging with a large country which has consistently low inflation over a period exerts direct influence on the inflation rate of the pegging country. In other words inflation in the pegging country gravitates to the level of inflation in the anchor country. It gravitates because inflation has to be brought down to maintain competitiveness. Thus, with expectations working in the right direction, price stability is quickly achieved. Though quite successful in controlling inflation, it is alleged the central bank loses its independence to the pegging country and is forced to contract or expand policy depending on the tendency of the exchange rate alone. The growth objective and independent response to domestic/external shocks are totally sidelined. Rather the shocks of the anchor country transmit to the pegging country. In such situations the economy is vulnerable to speculative attacks.

[42] Mishkin (1997), Mishkin (1999), Obsfeld and Rogoff (1995a)

For example, when inflation in the United Kingdom reached the order of 15 percent in October 1989, and continued at around that level until September 1990, a hard peg was introduced under the European Exchange Rate Regime (ERM) to bring down inflation, but the restrictive interest rate regime could not be maintained as the economy went into recession. The interest rate was lowered. With a lower interest rate, parity with the restrictive German monetary policy could not be maintained and interventions failed to offset large scale selling of Sterling, which ultimately led the United Kingdom to pull out of ERM in late 1992. Subsequently, a search for an alternative nominal anchor led the United Kingdom to follow an inflation target (Bowen 1995).

Another failure of the fixed exchange rate regime was experienced in Sweden, which had a fixed exchange rate for a very long period with occasional realignment. From the end of 1989, the krona suffered several speculative attacks, which the Riksbank fended off without any devaluation. However, two consecutive speculative attacks in September and November 1992 were too severe to be defended and in November 1992, some 160 billion krona of foreign exchange was lost, inducing the Riksbank to float the krona. Thus, the traditional nominal anchor of the monetary policy was lost. However, price-stability was retained as the goal of monetary policy. In January 1993, the Riksbank announced the policy of achieving a CPI inflation rate of 2 percent with a tolerance interval of plus minus 1 percent for 1995 and later years (Svensson 1995).

Strict monetary targeting, which requires constant-money-growth for a chosen monetary aggregate, is rarely practiced; a significant deviation from targets can be sighted across different countries such as the United States (McCallum 1989:10). Though capable of coping with domestic problems and allowing the central bank more independence than exchange rate targeting, its success is highly dependent upon the stability of money demand function and the controllability of the chosen target. Both these factors are important in the formation of expectations about future inflation. An unreliable relationship puts a question mark on the central bank's ability to control inflation and meet other commitments, as happened in the case of Canada and Australia (Grenville 1997).

However there are a few success stories of inflation control through monetary targeting as in the case of Germany and Switzerland. But Germany is alleged to react asymmetrically to target misses, raising interest rates in response to overshooting of the money-growth, but choosing not to lower interest rates in response to undershooting. Both have long-term objectives of price stability and the Bundesbank and Swiss National Bank actively engage in communicating the strategy of monetary policy to public, thereby enhancing the transparency of monetary policy and accountability of the central bank Mishkin (1999). Mishkin considers them "hybrid" inflation targeting as their practices are closure to inflation targeting than Friedman-like monetary targeting.

Inflation targeting involves a public announcement of a medium-term numerical target for forecasted inflation that the central bank has pre-committed. However, in practice the central bank is assigned an inflation target to be achieved. This leads to a clear objective for the central bank with increased accountability and transparency. It focuses on domestic considerations and uses all available information to arrive at the target, which provides it with an edge over narrow targeting. With inflation as the target of monetary policy, such countries have registered impressive success in achieving their targets under required bands (see Table 3.2). However, it is worth noting that all those countries, which have successful record of using inflation targeting, had low inflation rates at the time of its implementation. The interesting question is whether inflation targeting would produce similar results in countries experiencing higher inflation rates.

Although, it is too early to make a complete assessment of this new framework of monetary policy, it has nevertheless, generated considerable interest among central banks. In view of the fact that the idea of inflation targeting is on the current agenda of discussion in Indian policy circles, details of its pre-requisites will be discussed in the following section 3.6

3.6 INFLATION TARGETING:

Literature on the analytical framework of inflation targeting includes *inter-alia* works such as Leiderman and Svensson (1995), McCallum (1996), Haldane (1997, 1997a), Svensson (1996, 1997, 1997a, 1997b, 1997c, 1999, 2000), and Bernanke and Mishkin (1997). Svensson's (2000) analysis of open economy inflation targeting has particular emphasis on the exchange rate channel in monetary policy. Based on the existing literature a brief conceptual framework of inflation targeting in a highly simplified version of a closed economy case is presented in section 3.6.1 followed by the specific features of inflation targeting in section 3.6.2. The chapter conclusion is presented in section 3.7.

3.6.1 Conceptual Framework of Inflation Targeting

Let the central bank have a long-run socially optimal inflation target π^* and two short-run goals of stabilizing output and inflation around the long-run inflation target.[43] The central banks' period loss function can be written as,

$$L(\pi_\tau, y_t^\Delta) = \frac{1}{2}[(\pi_\tau - \pi^*)^2 + \lambda y_t^{\Delta 2}] \tag{3.27}$$

λ>0 represents relevant weight on output stabilization (for λ=0 it becomes single goal objective). With $0 < \delta < 1$ as discount factor the intertemporal objective function become

$$\min_{i_t} E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} L(\pi_\tau, y_\tau^\Delta) \tag{3.28}$$

Subject to:

Supply function: $$\pi_{t+1} = \pi_t + \alpha_y y_t^\Delta + \varepsilon_{t+1} \tag{3.29}$$

Demand function: $$y_{t+1}^\Delta = \beta_y y_t^\Delta - \beta_r (i_t - \pi_t) + \eta_{t+1} \tag{3.30}$$

where y_t^Δ is output gap (log actual relative to potential output), $\pi_t = p_t - p_{t-1}$ is inflation rate, i_t is monetary policy instrument (say short-term interest rate), p_t is log of price level, η_t, and ε_t are white noise shocks in year t and are not known in year $t-1$. Coefficients α_y and β_r are positive, while β_y is non-negative but less than one. The interest rate affects output with one-year lag, and hence inflation with two-year lags, thus two year is the control lag in the model. Transmission channels include an aggregate demand channel and expectation channel. With the aggregate demand channel, monetary policy affects aggregate demand, with lag, via its effect on the short-run real interest rate and credit availability. Aggregate demand then affects inflation, with another lag, via an aggregate supply equation probably like a

[43] In a more general set up a central bank can include several other variables such as exchange rate and interest rate in its loss function. However, such considerations will reduce the weight on inflation stabilization. For expositional simplicity, only two-variable loss function is considered here.

Phillips curve. The expectation channel allows monetary policy to affect inflation expectations, which, in turn, affect inflation, with a lag, via wage and price setting behavior.

Taking expectations of equation 3.30, the central bank's reaction function can be written as follows.

$$i_t = \pi_t - \frac{1}{\beta_r} y^{\Delta}_{t+1|t} + \frac{\beta_y}{\beta_r} y^{\Delta}_t \tag{3.31}$$

Now, equation 3.31 will represent the optimal reaction function of the central bank if the forecasted value of output gap, $y^{\Delta}_{t+1|t}$ is chosen optimally. In order to find optimal $y^{\Delta}_{t+1|t}$ the optimization problem is carefully formulated as follows. Equations (3.29) and (3.30) can be expressed as equations (3.32), (3.33) and (3.34), where (3.34) is obtained by advancing equation (3.29) one period ahead and using the relationship obtained in equations (3.32) and (3.33).

$$\pi_{t+1} = \pi_{t+1|t} + \varepsilon_{t+1} \tag{3.32}$$

$$y^{\Delta}_{t+1} = y^{\Delta}_{t+1|t} + \eta_{t+1} \tag{3.33}$$

$$\pi_{t+2|t+1} = \pi_{t+1} + \alpha_y y^{\Delta}_{t+1} = \pi_{t+1|t} + \alpha_y y^{\Delta}_{t+1|t} + (\varepsilon_{t+1} + \alpha_y \eta_{t+1}) \tag{3.34}$$

With the above transformations, the problem of dynamic program can be stated in terms of the value function as follows with one-period-ahead expected output gap $y_{t+1|t}$ as the state variables.

$$V(\pi_{t+1|t}) = \min_{y_{t+1|t}} \left\{ \frac{1}{2} \left[(\pi_{t+1|t} - \pi^*)^2 + \lambda \, {y^{\Delta}_{t+1|t}}^2 \right] + \delta E_t V(\pi_{t+2|t+1}) \right\} \tag{3.35}$$

$$\text{Subject to: } \pi_{t+2|t+1} = \pi_{t+1|t} + \alpha_y y^{\Delta}_{t+1|t} + (\varepsilon_{t+1} + \alpha_y \eta_{t+1}) \tag{3.36}$$

Let the conjectured solution of the above problem be as given in equation (3.37)

$$V(\pi_{t+1|t}) = k_0 + \frac{1}{2} k (\pi_{t+1|t} - \pi^*)^2 \tag{3.37}$$

Using the corresponding Bellman equation for the above problem and the conjectured solution of (3.37) the first order condition can be obtained as follows.

$$\pi_{t+2|t} - \pi^* = -\frac{\lambda}{\delta \alpha_y k} y^{\Delta}_{t+1|t} \tag{3.38}$$

Equation (3.38) is at the heart of the concept of the inflation targeting problem (Svensson 1999). It says that select the instrument such that deviation between the two-year conditional inflation forecast is $\frac{\lambda}{\delta \alpha_y k}$ times the negative of the one-year output-gap forecast. The above relationship is derived involving both inflation and output forecast. In case only inflation forecast is involved in the targeting rule, λ =0, the strict inflation targeting rule is obtained as:

$$\pi_{t+2|t} = \pi^* \tag{3.39}$$

Equation (3.39) says 'set the instrument such that the conditional inflation forecast at the two-year horizon (or, more generally, at the shortest horizon at which inflation can be affected) equals the inflation target' (Svensson 1999:629). Advancing (3.29) by one period and taking expectation the expected output gap in period t, the one period ahead conditional forecast of output gap can be written as

$$y^{\Delta}_{t+1|t} = \frac{1}{\alpha_y}(\pi_{t+2|t} - \pi_{t+1|t}) \tag{3.40}$$

Using equation (3.40), the first order condition (3.38) can also be written as follows:

$$\pi_{t+2|t} - \pi^* = c(\lambda)(\pi_{t+1|t} - \pi^*) \tag{3.41}$$

Where $c(\lambda)$ is defined as $c = \frac{\lambda}{\lambda + \delta\alpha_y^2 k}$, which fulfills $0 \le c < 1$ and $\frac{\partial c}{\partial \lambda} > 0$, $\frac{\partial c}{\partial \alpha_y} < 0$.[44] Now, the targeting rule of the form of equation (3.41) says 'set the instrument such that the two-year conditional inflation forecast's deviation from the inflation target is the fraction $c(\lambda)$ of the one-year conditional inflation forecast's deviation'.

Using the first order condition (3.38) and relationships presented in equations (3.40), (3.41), and (3.29), the optimal reaction function (3.31) can now be written as follows:

$$\begin{aligned} i_t &= \pi_t + \frac{\delta\alpha_y k}{\beta_r \lambda}\left(\pi_{t+2|t} - \pi^*\right) + \frac{\beta_y}{\beta_r} y_t^\Delta = \pi_t + \frac{\delta\alpha_y k}{\beta_r\left(\lambda + \delta\alpha_y^2 k\right)}\left(\pi_{t+1|t} - \pi^*\right) + \frac{\beta_y}{\beta_r} y_t^\Delta \\ &= \pi_t + \frac{\delta\alpha_y k}{\beta_r\left(\lambda + \delta\alpha_y^2 k\right)}\left(\pi_t - \pi^*\right) + \frac{1}{\beta_r}\left(\frac{\delta\alpha_y^2 k}{\lambda + \delta\alpha_y^2 k} + \beta_y\right) y_t^\Delta \\ &= \pi_t + \tilde{b}_\pi(\pi_t - \pi^*) + \tilde{b}_y y_t^\Delta \end{aligned} \tag{3.42}$$

here $\tilde{b}_\pi = \frac{\delta\alpha_y k}{\beta_r\left(\lambda + \delta\alpha_y^2 k\right)} = \frac{1 - c(\lambda)}{\beta_r \alpha_y} > 0$ and $\tilde{b}_y = \frac{1}{\beta_r}\left(\frac{\delta\alpha_y^2 k}{\lambda + \delta\alpha_y^2 k} + \beta_y\right) = \frac{1 - c(\lambda) + \beta_y}{\beta_r} > 0$. Thus, the optimal reaction function (3.42) says that the instrument interest rate is increasing in excess of the two-year inflation forecast over the inflation target, or in excess of current inflation over the inflation target, in addition to increasing in output. Weight on output stabilization motivated a gradual adjustment of the inflation forecast towards the long-run inflation target. Less weight on output stabilization means faster adjustment towards the long-run inflation target. In the case of pure inflation targeting the reaction function reduces to the following, which is similar to the Taylor rule.

$$i_t = \pi_t + \frac{1}{\beta_r \alpha_y}\left(\pi_t - \pi^*\right) + \frac{1 + \beta_y}{\beta_r} y_t^\Delta \tag{3.43}$$

[44] See (Svensson 1997) for proof and derivation of 'k'.

3.6.2 Features of Inflation Targeting

Three main features of inflation targeting emerge prominently, and have received most attention in the literature. (1) Provision of a nominal anchor in the form of a socially optimal inflation target for monetary policy and inflation expectations; (2) central bank's independence, increased transparency and accountability of the procedures with commitment of reducing inflation bias of the monetary policy; and (3) an explicit role given to the lags of monetary policy in period by period choice of instrument setting and ability to forecast inflation closely. Given these features, important prerequisites are drawn for implementation and monitoring of IT framework.

3.6.2.1 Overriding Commitment for Inflation Target

Giving more weight on the variable other than inflation in the loss function of the central bank leads to an increase in the variance of expected inflation and therefore likely more variation in the realized inflation. This requires setting a wider band for the target inflation. More effective inflation targeting can be achieved by sacrificing any firm commitment by authorities to target the level or path of any other nominal variable like exchange rate, wages or output. Only some degree of stabilization could be committed, while inflation enjoys overriding priority.

3.6.2.2 Central Banks Independence

The central bank should be capable of conducting monetary policy with a degree of independence, in the sense that the central bank should be able to gear freely the instruments of monetary policy towards the attainment of some nominal objective. This only means instrument independence and not goal independence. The goal can be the social optimal value.

The independence of monetary policy is linked to fiscal dominance. Therefore, it is required that direct public borrowing from the central bank be as low as possible. The government should develop its own broad revenue base and not depend significantly upon revenue from seigniorage. Fiscal driven inflation arising out of monetisation of the deficit undermines the effectiveness of monetary policy. In particular, the independence of the central bank in developing countries is alleged to be greatly compromised inter-alia, due to a weak banking system, shallow capital market, administered interest rates, selective credit policy, compulsory placement of public debt and heavy reliance on seigniorage (see Fry (1993); Fry, et al. (1996); Mas (1995); Cukierman (1992)).

Masson, et al. (1997) considers that a country facing inflation of the order of 15-25 percent for a number of consecutive years will be unable to rely on monetary policy alone to target any significant and lasting reduction in the rate of inflation.

3.6.2.3 Model for Inflation Forecast

As discussed earlier, inflation targeting implies inflation forecast targeting where forecasted inflation becomes the intermediate target. The monetary instrument (say repo rate) is adjusted during the control period so that the forecast exactly coincides with the long-term inflation target set by the central bank as the socially optimal value. Therefore, the success of inflation targeting hinges on the efficiency of the inflation-forecasting model. Forecasting errors associated with model specification, identification of true shocks, projection of exogenous variables and probability distribution of inflation outturn are critical.

This calls for a sensitivity analysis with baseline projections for different assumed paths of exogenous variables to get an idea of probable uncertainties around baseline projection. The baseline projection is also required to be modified to accommodate off-model information like policy-makers judgments and monetary aggregate through continuous practice of working with forward looking operating procedures and determination of lags in monetary transmission. Efficient forecasting may thus require experimenting with structural changes in model and off-model information. All the sources of imperfect controls e.g. aggregate demand and supply shocks, instability of velocity, information asymmetries; instrument instability and other information variables can be considered in arriving at the forecasted inflation, which is an intermediate target in this case.

3.6.2.4 Features of Inflation Targeting Countries

This section provides a survey of common practices followed in some of the inflation targeting countries based on current literature (for example Leiderman and Svensson (1995), Masson, et al. (1997), Debelle (1997), Hoffmaister (1999)). A summary feature of inflation targeting countries is provided in Table 3.3.

In many of the IT countries IT was adopted after disappointment with monetary targeting. For some it was adopted in the aftermath of a failed attempt to use the exchange rate as the main anchor of monetary policy (e.g., the U.K., Sweden, and

Finland). In others, like Canada and Australia, it was a breakdown of the relationship between monetary aggregate and inflation that prompted the use of inflation targeting.

Table 3.3 Summary of inflation targeting framework in selected countries

	New Zealand	Canada	United Kingdom	Sweden	Finland	Australia	Spain
Date first instituted	March 1990	February 1991	October 1992	January 1993	February 1993	Early 1993	Summer 1994
Inflation at adoption (%)	5.8	4.8	3.8	2.3	2.6	1.0	4.7
Target inflation (%)	0-3	1-3	1-4	2	2	2-3	<3
Time frame	5 years (to 1998)	Through end-1998	By spring 1997, 2.5% or less thereafter	1996 onwards	1996 onwards	On average over the cycle	By late 1997, <2% thereafter
Inflation during 1999	-0.1	1.7	1.6	0.5	1.2	1.5	2.3
Inflation during 2000	-0.1	2.7	2.9	1.0	3.4	4.5*	3.4
Inflation measure	CPI	CPI	Retail Price Index	CPI	CPI	CPI	CPI
Factors excluded from CPI	Interest cost, indirect taxes, govt. charges and significant changes in terms of trade	Food, energy, and the effect of indirect taxes	Mortgage interest payments	None	Mortgage interest, indirect taxes, govt. subsidies, house prices	Mortgage interest payments, indirect taxes, other volatile items	None
Target announcements	Defined in policy target agreement between the Minister of Finance and the Central-Bank Governor	Joint agreement between the Minister of finance and the Central-Bank Governor	Chancellor of the exchequer	Bank of Sweden (Riksbank)	Bank of Finland	Reserve Bank of Australia	Bank of Spain
Inflation report	Quarterly since March 1990	Half-yearly since May 1995	Quarterly since February 1993	Quarterly since October 1993	No	Yes Semi-annual statement	Semi-annual
Inflation Forecasts published?	Yes	No	Yes	No	No	No	No

Sources: Debelle (1997); Masson, Savastano, and Sharma (1997); Hoffmaister (1999); CPI inflations for the periods 1999 and 2000 are taken from IFS April 2001 which does not exclude the volatile components. * Australia experienced high inflation during 2000 due to implementation of goods and services tax (GST), the underlying inflation was about 2 %.

The central bank independence (CIB) ranking of these countries in terms of less fiscal dominance, and ability to operate monetary policy instruments is below 12

(Cukierman 1992) as against 21 for India (a lower rank is considered better). The central banks in these countries use the short-term interest rate as their main operating instrument and their financial market is considered well developed to allow for efficient transmission of monetary actions. Also, inflation in these countries at the time of adoption was considerably low, which reduced the risk of cost associated with bringing down inflation while at the same time low inflation provided them with a degree of credibility before actually committing themselves.

Underlying inflation based on the consumer price index (CPI) with a bandwidth appears to be the preferred target in most cases, with some preferring to target headline inflation. The target ranges are to be achieved within an announced time horizon between one to two years. In most cases the inflation targets were set by the central bank or by mutual agreement between fiscal and monetary authorities and the inflation reports published for public information. New Zealand and the U.K. also publish the inflation forecast, which increases their credibility and commitment.

3.6.2.4 Design & Operational Considerations in Inflation Targeting

The literature[45] on designing, implementing and monitoring an inflation target based monetary regime highlights the need to address several issues. One of the major issues relates to the choice between price level targeting and inflation level targeting. Under a price level objective, deviations in price level from the target require to be offset. Thus, a price rise requires a deflation to reduce the price level, which may result in greater variability of inflation. Under a policy that cares only about the inflation target, such a price rise is permanent; policy ensures that the inflation rate returns to the target level, but no attempt is made to restore the initial price level. Bygones are bygones. It has been pointed out that, in the case of inflation targeting with random errors, uncertainty about future price level increases with the forecast horizon and hence price level forecast may be preferable (Fischer 1994, Svensson 1996).

However, inflation stability is more common than price level stability. Even in Countries with legislative price-stability objectives, such as New Zealand, the operational conduct of policy has focused on achieving a desired inflation target

[45] Yates (1995), McCallum (1996), Svensson (1997), Haldane (1997), Haldane (1997a), Masson, et al. (1997), Debelle (1997), Hoffmaister (1999).

(Walsh 1998:326). With this consideration, the necessary issues are discussed in reference to inflation stability.

Level of Target

There is no uniform opinion among economists regarding the desired level of inflation. At present almost all of the inflation targeting countries have a positive (rather than zero) rate as their inflation target. According to the Bank of International Settlements (BIS), 2 to 3 percent often surfaces in discussions in industrial countries, taking into account the difficulties in statistical measurements and relative price adjustments taking place due to differential productivity trends in various sectors (BIS 1998). Some argue that the inflation target in rapidly developing countries needs to be somewhat higher because (i) relative price adjustments will be more significant in economies where productive gains in tradable sectors will be large and (ii) price liberalization in the presence of downward rigidity in prices is likely to increase inflation. A two percent rate of inflation is considered by some central banks (e.g. Bank of England, Bundesbank) as tantamount to price stability (Feldstein 1996). Due to rigidities in prices, some economists (e.g. Summers (1991)) favor small single strict inflation of 2 to 3 percent in the long term. Fischer (1994) suggested a range of 1 to 3 percent.

Target Band

To allow for the variation in target measurements, constraints in fine-tuning and dampening the effects of supply shocks, most inflation targeting countries have an explicit band for inflation. However, too wide a band can render slackness in monetary discipline. Analytically, the band can be interpreted as a confidence interval, proportional to the unconditional standard deviation of inflation, the square root of the sum of the variance of the conditional expectation of inflation and the variance of the inflation forecast error (Svensson 1997).

When the central bank's loss function has multiple goals (e.g. output, exchange rate stabilization) in addition to inflation then the band for realized inflation incorporates the unconditional variance of the deviation of inflation forecast (short-run inflation targets) from the inflation target (the long-run inflation target), in addition to the variance of forecast errors. The implicit band for inflation forecast is an increasing function of the weight on additional goals. A wide band then indicates a significant stabilization goal of the central bank.

Time Dependence and Speed of Approach to Target

Speed to approach the inflation target depends on the level of current inflation and the needs of stabilization of output and other goal variables, as there is a trade-off between the variability of inflation forecast from the target and the stabilization of output and other goals. Some economists prefer a gradual reduction in inflation to cold turkey while others prefer fast reduction. For example (Ball 1994b) considered a gradual reduction of inflation costly in real terms as opposed to fast reduction. On the other hand, a slower adaptation to a new regime irons out the difficulty and learning problems of the process without losing the much-needed credibility. It can also be set as medium term and long-term goals. For example, in the UK the target has been 1 to 4 percent in medium-term and 1 to 2.5 percent in the long run.

Monetary Transmission (Control) Lag

The monetary policy actions affect the final goal variables with a lag. The transmission lag may be long or short but at the same time it may also be unstable. In the case of inflation targeting, knowledge about the lags in monetary transmission is critical. The central bank's inflation forecast must be formed in advance by a period at least equal to the lag in monetary transmission. Haldane (1997a) has addressed this issue and shown that underestimating the monetary lag may have a more damaging effect on inflation control than overestimating it; in certain situations underestimating may lead to explosive cycles. Thus, a forward- looking dimension in monetary policy may be necessary.

Operational Considerations

Among the key operational considerations of inflation targeting is the prompt ability of monetary authorities to counter the effects of possible external shocks arising from unforeseen changes in exchange rate, import-price, foreign output, or climatic-change. While there is little conflict in resolving the price and output conflict arising from demand shocks, it would be a formidable problem if the conflict in stabilizing price and output arise from supply shock.

Instrument Instability

Instrument instability is indicated by the increase in variance of the real interest rate and the real exchange rate consequent upon the need to swing the interest rate and exchange rate in order to maintain the target around a narrow inflation target band. A frequent swing may result from the particular nature and type of shocks, instrument effectiveness and the target band.

Transparency and Credibility

It is argued that transparency forces the central bank to continuously improve its analyses. Under inflation targeting, the central bank pre-commits itself to an objective, which require most accurate knowledge about the structure of the economy, the transmission mechanism of monetary policy and the possible outcomes of the policy. Failure to do this will result in missing the target and loss of credibility. At the same time, too much flexibility to accommodate inadequate knowledge also leads to a loss of credibility. Therefore, sometimes central banks may need to mix simple rule with discretion by announcing an inflation target along with an escape clause.

3.7 CONCLUSION AND COMMENTS IN RELATION TO INDIA

This chapter has presented a survey of the developments that have led to the current framework of conducting monetary policy. Financial market volatility has led modern central banks to choose interest rates as the main instrument for conducting monetary policy, and at the same time a breakdown of the stable relationship between output and monetary aggregate and the failures of exchange rate pegs has motivated most central banks to adopt an inflation rate as the primary goal of monetary policy. Recently, inflation forecasting has emerged as one of the key intermediate targets for monetary policy because of the argument that it is to be highly correlated with the socially optimal inflation rate, the goal variable.

From the foregoing discussion, it is clear that among the different monetary regimes inflation targeting on the one hand requires relatively more discipline in terms of fiscal management and central bank independence while on the other hand it requires greater financial depth and sophistication in manipulation of instruments. Developing countries, such as India, find it hard to qualify on these accounts. With the combined fiscal deficit of Central and State Governments (during 1990s) remaining in the range of 8-10 percent of gross domestic product (GDP), more than 25 percent of the time and demand liability of the banking sector held in government securities as SLR and the ratio of gross to net borrowing of the government resting around 0.67 does not bode well central bank independence in India. Because of the high fiscal deficit the central bank finds it difficult to reduce CRR drastically. In order to avoid interest rates rises in the face of otherwise borrowing needs of the Government the RBI is constrained to finance it at lower cost.

There has been no liberalization in the area of directed credit. Commercial banks are required to direct 40 percent of their commercial advances to the priority sector, which consists of agriculture, small-scale industry, small-scale transport operators, artisans etc. At present the percentage of directed credit appears to be too high and needs to be narrowed down to potentials growth and highly focused areas.

Further the reforms are a very recent phenomenon in India. Financial depth is beginning to develop. Thus, it will take quite some time before the pre-requisites of inflation targeting as available in the developed economies is achieved in India. After the financial sector reforms commencing in 1991 the situation must have improved particularly with the abolition of automatic monetisation, decontrol of most of the deposits and lending rates and reduction in quantitative controls since 1997. Therefore, it does not prevent the monetary authorities in India from commencing the process of inflation targeting. The spirit of the monetary regime directed towards inflation control need not necessarily be the exact inflation targeting, practiced in developed countries. The most important thing is to understand the behaviour of the economy and develop an inflation model based on the maximum available information and start working with model improvements as time passes. The objective of this report has the same spirit.

Chapter 4

The Inflation-Growth Nexus in India

4.1 INTRODUCTION

Achieving and sustaining high economic growth has been the top priority of policymakers around the world. While the process of achieving high growth may lead to an increase in inflation due to the pressure on inputs exerted by the excess demand, sustaining the growth requires that inflation be kept under control. In the long run, inflation reduces growth by reducing the efficiency of investment and productivity growth. Several recent studies, for example, Fischer (1993), Gregorio (1993), Barro (1995), Fry, et al. (1996), Ambler and Cardia (1997), and Ghosh and Phillips (1998) have shown a long-run negative relationship between inflation and growth based on cross-country and panel regression analyses. Corden (1996) observed that one of the strong features of newly industrialized economies like Singapore, Taiwan, Malaysia, and Thailand was very low levels of inflation over a long period between 1961-91. During this period these countries had an average annual inflation level ranging between 1.7 and 4.0 percent.

Although there is no single optimal level of inflation, two per cent inflation is considered a benchmark of price stability by Feldstein (1996) and certain other studies.[46] The inflation targeting countries also have inflation targets in a similar range of 1-3 percent. On several occasions, the then Governor of the Reserve bank of India (RBI), Rangarajan (1998), stressed the need for bringing down the inflation

[46] Fischer (1994) suggests a range of 1-3 percent; Summers (1991) considered that optimal inflation should be positive; 'perhaps 2-3 percent' as the losses from a low inflation level are likely to be small.

rate in India to be on par with its trading partners' level of inflation[47]. Rangarajan's concern seems to emerge from the following channel of adverse effect of inflation. For a given nominal exchange rate and foreign inflation, a higher rate of domestic inflation means a higher rate of appreciation for the domestic currency with an accompanying loss of export competitiveness. An adverse impact on exports may affect economic growth in different ways, such as a decrease in imports of technology and intermediate products, balance of payment pressures and a net fall in aggregate demand.

However, some other studies have concentrated on specifying a threshold level of inflation. For example Sarel (1996) and Bruno and Easterly (1998) show that the harmful effects of inflation are not universal, but appear only above the 'threshold' level of inflation. In a cross-country analysis, Sarel (1996) finds evidence of a significant structural break at 8 percent inflation in the function that relates economic growth to inflation.

Some country specific time series studies have explored the relationship between inflation and output (Bullard and Keating 1995), and inflation and productivity (Jarrett and Selody 1982 and Cameron, et al. 1996). However, these studies lack concentration on growth. If inflation is found to impact on the growth rate, this effect is likely to be more important than any one-off impact on the level of output or productivity (Grimes 1991). Grimes (1991) study is one among very few country specific studies which have tried to analyze the relationship between economic growth and inflation. Based on analysis of 21 industrialized countries, Grimes (1991) concludes that even a low rate of inflation is likely to be detrimental to economic growth.

Kannan and Joshi (1998) recently analyzed a small sample of Indian data from 1981-95 in a static model and concluded six percent as the threshold of inflation

[47] It can be pointed out that the widely quoted Chakarvarty Committee report (RBI 1985), recommended an inflation level of about four percent for India. On the relevance of this recommendation of the Chakravarty Committee report, Rangarajan (1998:63) observes 'No one in this country is advocating absolute price stability or even the order of price stability that is being sought as an objective in the industrially advanced countries'. Inflation during the recent period of 1991-98 in countries which are the major trading partners of India, like the United State of America (USA), Japan, Germany, United Kingdom and France has been at much lower levels of about 2.66, 1.04, 3.01, 2.95 and 1.76 percent, respectively, compared with 8.22 percent in India. It may be noted that average annual inflation in these countries for the entire sample period of 1971-98 was 5.10, 4.07, 7.71, 3.35 and 5.96, respectively compared with 8.2 percent in India.

before output growth is adversely affected. This could hardly have been a surprising result, given that the specific period contained only three points of less than six percent inflation. However, they considered a six percent inflation rate may be 'unacceptably high from the point of view of equity and other welfare considerations and may need to be contained at a feasible lower level' (Kannan and Joshi 1998:2727).

Such literature, which emphasizes the negative effects of inflation on output growth, casts serious doubts on an approach to conducting monetary policy, which tries to exploit a short-run trade-off between inflation and output. At the same time, if such a negative relationship exists, targeting inflation should become the central theme in conducting monetary policy. From this point of view, it is important to know the causal relationship between inflation and growth, particularly in view of the fact that inflation and economic growth are both endogenous variables.

It is in this context that this chapter examines the inflation-growth nexus in India using annual data for the period 1971-98. Particularly, the questions addressed in this chapter are: (1) Does inflation affects economic growth (measured by the growth of per capita real gross domestic product) in India, (2) whether there is a threshold level of inflation, and (3) Besides its direct effects, does inflation exert any indirect effect on economic growth through other variables? Specifically, how does inflation affect savings and investment in India? The period of this study is reasonable, given that it covers a variety of inflation episodes, while at the same time data on most other variables are systematically and reliably available beyond 1970.

The rest of the chapter is organized as follows: The pattern of inflation in India is discussed in the following section 4.2. Section 4.3 discusses the causal relationship between output growth and inflation is discussed. Estimation of the growth models with non-linear effect of inflation on growth is examined in section 4.4. The effect of inflation on savings and investment is modeled and examined in section 4.5, and section 4.6 presents the concluding remarks.

4.2 CHOICE OF INFLATION MEASURE

Five different price indices are published in India. Three are consumer price indices (CPI) targeted to three different groups of consumers. The other two are the gross domestic product (GDP) deflator and the wholesale price index (WPI). The three consumer price indices are: CPI (IW) for industrial workers (IW) calculated with 260 commodities; the CPI (UNME) for the Urban Non-Manual Employees (UNME) calculated with 180 commodities and CPI (AL) for Agricultural Labour (AL) calculated with 60 commodities (GOI 1996:77). However, CPI-AL, which has 1960-61 base weights, has become outdated due to the change in the consumption pattern of rural population (GOI 1994:58; 1996:77).

It should be noted that none of the above three CPI can be considered a general consumer price index in the same broad sense as is understood in developed economies and they are seldom used for policy analysis in India. Henceforth, a reference to CPI means CPI (IW), which is the broadest of the CPI measures. The other two measures of CPI will not be referred to at all in this study. The GDP deflator is an implicit price index, which can be derived from the national accounts for GDP, consumption or investment. It covers all three sectors of services, industry and agriculture and largely represents producer prices. However, the GDP deflator can be known only with a big lag in the order of two to three years when accounts are final. At the same time, it is not well understood by the economic agents compared with the directly published prices indices. Further, in the context of monetary policy analysis, information on price movements are needed at quick intervals in order to allow policy makers to forecast inflation trends and take the necessary measures. Probably due to these reasons the GDP deflator is not a popular measure of price index for analyzing the Indian economy.

The wholesale price index (WPI) includes service charges from wholesalers and retail profits; it covers 447 commodities spread over primary articles, fuel products, and manufactured items. However, it does not include the services sector per se. WPI is by far the most commonly used index for the following reasons. First, WPI estimates are available with a lag of just two weeks compared to CPI, which is available with a one-two month lag. Second, the WPI has an economy-wide coverage of price movements and moves closely with the GDP deflator.

The difference between the CPI and WPI also stems from the different composition of the basket of commodities and the weight given to them. For instance, the WPI includes manufactured goods with a weight (1980-81 base) of 57 percent in the basket, while primary articles account for 32 percent of which food items have a weight of 17.4, excluding manufactured food, and the remainder about an 11 percent weight is given to fuel, power, light and lubricant. In contrast, the CPI has a weight of about 57 percent for food articles alone. Thus, the WPI has a lesser weight to volatile elements and can be considered a closer proxy of core inflation. Finally, the WPI captures larger components of import, which reflects on domestic inflation.

It is also emphasized here that monetary authorities must be fully aware of the broadest possible inflation and any model of inflation must be able to explain price variations as a whole. Therefore, the WPI has been adopted as the preferred measure of price index in this study. Henceforth, any reference to price in this thesis, means the WPI unless otherwise specifically stated.

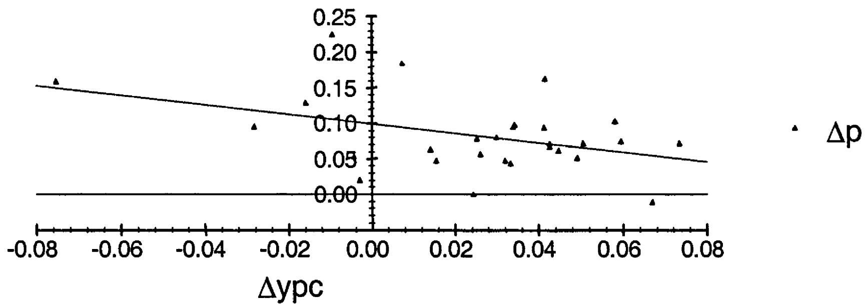
4.3 CAUSAL RELATIONSHIP BETWEEN GROWTH AND INFLATION IN INDIA

Inflation and output growth are endogenous variables and both may be argued to respond to change in the other. Therefore, as suggested by Sims (1972), it is important to examine the direction of causality and the legitimacy of their precedence. The scatter plot between inflation and per capita output growth for the period 1971-98 is presented in Figure 4.1, panels a to c. As discussed above, the wholesale price index converted to base years 1993-94 has been chosen as the preferred price index in this study. Economic growth is measured by the growth of per capita real gross domestic product with base years 1993-94. The per capita real output (real gross domestic product) is represented by YPC, while price is represented by P. Logs of the variables are expressed by their lower case letters, and the first difference is expressed by placing a Δ before the variable. Thus, Δypc represent the growth rate of real output per capita (economic growth) and Δp represents the inflation in fractions.

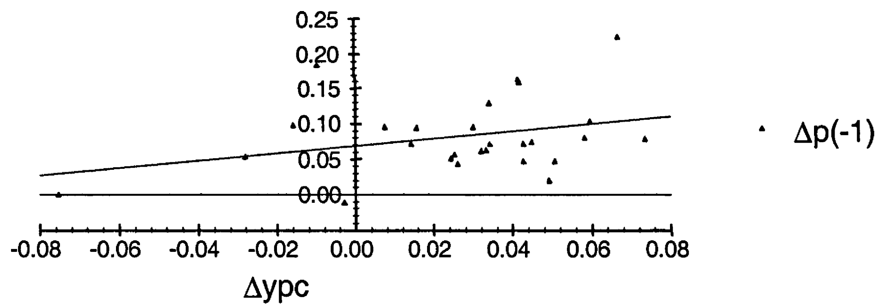
It is clear from Figure 4.1 (panel a), that there is evidence to suggest a negative relationship between contemporaneous inflation and economic growth. Lagged inflation and economic growth appear to be positively related (panel b), while lagged economic growth and inflation appear to be negatively related (panel c). The contemporaneous relationship is also negative (panel a). Thus, while the panel-b result is intuitive, the other two results appear to be counter-intuitive and need further analysis. In addition graphs in Figure 5.1 do not reveal anything about the direction of causality. The relationship between the contemporaneous and lagged or future variables can be exploited using statistical methods to establish the direction of causality and hence the precedence between these two variables as a first step to further analysis.

Figure 4.1 Scatter plot of inflation (Δp) and per capita real GDP growth (Δypc) (1971-98)

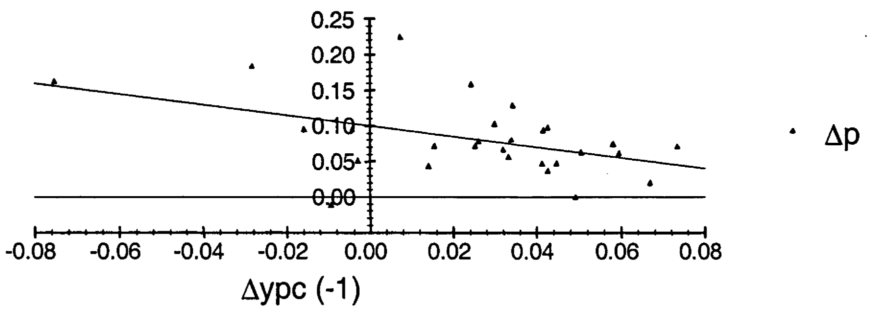
(a) Contemporaneous relationship



(b) Lagged inflation and contemporaneous per capita real GDP growth



(c) Lagged per capita real GDP growth and contemporaneous inflation



There are different forms, in which such causality tests can be undertaken. Hsiao (1979) and Jacobs, et al. (1979) argue that different studies, which use the same data set but different methods of testing, often report results that are not in conformity with one another. Therefore, this study uses the two tests described below before arriving at the conclusions.

Granger Non-Causality Test

The multivariate version of the Granger non-causality test is known as the 'block Granger non-causality test', which can be carried out in a VAR set up. Following Hamilton (1994:309), and Pesaran and Pesaran (1997:121-131), the concept of the 'block Granger non-causality test' can be described as follows: Consider the following simple VAR of order p for a $m\,x\,1$ vector z_t of jointly determined endogenous variables.

$$z_t = a_0 + \sum_{i=1}^{p} \Phi_{i,} z_{t-i} + u_t \qquad (4.1)$$

Now, suppose the variables of VAR are categorized into two groups as represented by $m_1\,x\,1$ vector of subset z_{1t} and $m_2\,x\,1$ vector of subset z_{2t} such that $z_t = (z_{1t}^{'}, z_{2t}^{'})$ and $m_1 + m_2 = m$. Then z_t can be decomposed into two blocks as follows.

$$z_{1t} = a_{10} + \sum_{i=1}^{p} \Phi_{i,11} z_{1,t-i} + \sum_{i=1}^{p} \Phi_{i,12} z_{2,t-i} + u_{1t} \qquad (4.2)$$

$$z_{2t} = a_{20} + \sum_{i=1}^{p} \Phi_{i,21} z_{1,t-i} + \sum_{i=1}^{p} \Phi_{i,22} z_{2,t-i} + u_{2t} \qquad (4.3)$$

Here, a_{10} and a_{20} are $m_1\,x\,1$ and $m_2\,x\,1$ vectors of constants respectively and $\Phi_{i,11}$, $\Phi_{i,12}$, $\Phi_{i,21}$, and $\Phi_{i,22}$ contain autoregressive coefficients. The subset z_{1t} is said to be block exogenous in the time series sense with respect to the variables in subset z_{2t} if the elements in subset z_{2t} are of no help in improving a forecast of any variable contained in subset z_{1t} that is based on the lagged values of all the elements of z_{1t} alone. In the system defined by equations (4.2) and (4.3) z_{1t} is block exogenous when $\Phi_{i,12}$=0 for $i=1,2,...,p$. In other words, the hypothesis that the subset z_{2t} does not 'Granger-cause' z_{1t}, which means z_{1t} is block exogenous, is defined by

$$H_G : \Phi_{12} = 0, \text{ where}, \Phi_{12} = (\Phi_{1,12}, \Phi_{2,12}, ..., \Phi_{p,12}). \tag{4.4}$$

Sims Non-Causality Test

In a seminal paper about the implications of the Granger causality, Sims (1972) proposed an alternative way of testing Granger non-causality. Following Hamilton (1994:304) Sims' proposition can be stated as follows. Consider following a linear projection of y_t on past present and future x's, with b_j and d_j defined as population projection coefficients, that is the value for which $E(\eta_t\ x_\tau) = 0$ for all t and τ. E is an expectations operator.

$$y_t = c + \sum_{j=0}^{\infty} b_j x_{t-j} + \sum_{j=1}^{\infty} d_j x_{t+j} + \eta_t \tag{4.5}$$

Then, y fails to Granger -cause x if and only if d_j=0 for j=1,2....

As pointed out in Hamilton (1994:305) a problem with Sims' form is that the error term η is in general autocorrelated. Thus, a standard F test of the hypothesis that d_j=0 for j=1,2, --- in (4.5) will not give the correct answer. To overcome this problem and still be able to carry out a Sims type bivariate-test of Granger non-causality Geweke, et al. (1983) (also see Hamilton 1994 ch.11 for more details) suggested the following modified specification.

$$y_t = c - \sum_{j=1}^{\infty} \alpha_j y_{t-j} + \sum_{j=0}^{\infty} \beta_j x_{t-j} + \sum_{j=1}^{\infty} \gamma_j x_{t+j} + v_t \tag{4.6}$$

The null hypothesis that y does not Granger-cause x can be tested by truncating (4.6) at some order p and carrying out a F test of γ_1=γ_2= ...= γ_p = 0. The assumption is that y did not cause x can be true if and only if the future values of x

do not have any power to explain the current value of y. In that sense it is also a test of the ability of y in forecasting x.

Considering that in the case of annual data contemporaneous variables can have powerful effects, the outcome of a Sims test, which includes contemporaneous term with the two-sided distributed lags, may give a different result compared to the block Granger non-causality test, which involves only lagged explanatory variables. Further, given the small size of the time series data, the order of the VAR is decided by using the Schwarz Bayesian Criterion (SBC) of model selection. After obtaining the lagged structure, the equations are estimated accordingly.

Both variables are stationary based on the ADF test (see Annexure 4.2 of this chapter) and the order selection criterion of the VAR supports the choice of order 1 for the bivariate system including Δp and Δypc. As both variables are stationary in the ADF test, the non-causality test in VAR of order 1 would be consistent. The results of the Granger block non-causality test and Sims' two-sided forecasting ability test are presented in Tables 4.1 and 4.2 respectively.

At the 10% significance level, the Granger block non-causality test (Table 4.1) does not rule out a possibility of bi-directional causation in VAR-1, while Sims' test (Table 4.2) rejects the unidirectional causation running from per capita output growth to inflation but does not reject causation running from inflation to per capita output growth. Thus, the hypothesis that inflation influences growth is not rejected by either of the tests.

However, in view of the fact that the block Granger non-causality test in VAR-1 suggests the existence of a bi-directional causation, it is important to see which of the two variables has a more persistent effect on the other. In order to verify this, the two tests are repeated such that the regression equations include lags of two, three and four. The estimated equations for each case are presented in Annexure 4.3 and 4.4 corresponding to Granger block non-causality tests and Sims tests, respectively. The results of the hypothesis tests are given in Tables 4.1 and 4.2.

With more lags in the system, the Granger block non-causality test now unambiguously rejects the hypothesis that inflation does not cause per capita output growth, but does not reject the hypothesis that per capita output growth does not cause inflation. A look at the estimated equations of Δp in Annexure 4.3 clearly shows that the coefficients of lagged Δypc are not significant and the VAR-1 result was not robust. On the contrary, inflation appears to have a more persistent effect on per capita output growth. Importantly, the conclusions from the Sims test remain unaltered. Thus, both tests now support unidirectional causation running from inflation to growth. And, it can be safely concluded that inflation is an important and legitimate explanatory variable in explaining economic growth in the case of India.

Table 4.1 'Block Granger non-causality' test between per capita real GDP growth and inflation in a bi-variate VAR. Direction of non-causality being tested is from x to y (1971-98)

	Test variable (lagged x)	Δp	Δypc
	Dependent (y)	Δypc	Δp
VAR - 1	CHSQ (1)	3.450 [0.063]	4.384 [0.036]
VAR - 2	CHSQ (2)	4.130 [0.130]	2.989 [0.224]
VAR - 3	CHSQ (3)	8.030 [0.045]	1.528 [0.676]
VAR - 4	CHSQ (4)	12.74 [0.013]	3.770 [0.438]

Note: P-values for Chi-Square statistics are given in square brackets []. The statistics are to test the null hypothesis in a Wald test that coefficients of the explanatory variables x in the equation of the y variable are zero according to the equation 4.5. A lower P-value means rejection of the hypothesis and therefore that demonstrates existence of the causal direction. Individual estimated equations are presented in Annexure 4.3 and 4.5.

Table 4.2 Sims test of forecasting ability between per capita real GDP growth and inflation in a bi-variate OLS regression. Direction of non-causality being tested is from y to x (1971-98)

	Test variable (future x)	Δp	Δypc
	Dependent (y)	Δypc	Δp
One past value of x and y and one future value of x	CHSQ (1)	1.620 [0.203]	3.507 [0.061]
Two past value of x and y and one future value of x	CHSQ (1)	0.618 [0.431]	5.460 [0.019]
Three past value of x and y and one future value of x	CHSQ (1)	0.176 [0.675]	8.650 [0.003]

Note: All equations include the contemporaneous value of x in accordance to equation 4.6. P-values for Chi-Square statistics are given in square brackets []. The statistics are to test the null hypothesis in a Wald test that coefficient of the future value of the x variable γ in the equation for the y variable is zero. A higher P-value means that the hypothesis of zero coefficients for future value of x is not rejected and therefore that demonstrates non-rejection of the non-existence of the causal direction from y to x supporting non-existence of causal direction from y to x. Estimation is done according to equation 5.6.

The regression results of the above test of causal relationships presented in Annexures 4.3 and 4.4 of this chapter clearly show that lagged inflation has a positive influence on economic growth, while contemporaneous inflation has a negative influence. In the subsequent section, the robustness of this relationship is tested by adding more variables related to economic growth.

While it may be simpler to argue that the past experience of higher inflation may be a motivation for higher production, it is not easy to interpret the negative effect of current inflation on growth. As mentioned at the beginning of this chapter, and as also discussed in Chapters 1 and 2, the literature dealing with inflation and output growth provide several explanations, depending upon whether the explanation is provided for stagflation or for cases of high growth with low inflation. In both cases, the standard conviction of the Phillips curve type trade-off is completely at odds. With inflation the purchasing power of the currency falls, and problems in clearing the goods market may arise due to imperfect competition, and or institutional rigidities. Thus, country specific characteristics facilitate in making an argument for the negative impact of current inflation on growth in India.

Drawing on the study of Bruno and Sachs (1985), it was emphasized early in Chapter 2 that a permanent increase in the relative price of a factor of production like raw material could shift the production frontier towards the origin. As capital is fixed in the short-run, the new equilibrium output and profit depend on the relative flexibility of the real wage and legal system regarding labour laws. While there is some kind of wage indexation in most organized sectors, Indian labour law does not allow employers to fire workers easily. With a relatively rigid real wage, unemployment should have increased but has not done so because of the protective labour laws. Where there are such protective labour laws, employment could be forced to remain unchanged in the short-run, which could also be due to technological reasons (for example putty-clay technology). The result is a fall in profit and output. International competitiveness is also reduced resulting in a loss of export demand. The market clearing output is lower, although the potential output based on capital and labour employed has not changed. In the long run if raw material prices revert and expectations are corrected, the system may back track to the original frontier.

As a result of inflation in inputs and intermediate goods, the general price level rises leading to reduced purchasing power of the currency. In the short run loss of purchasing power is not compensated with a commensurate increase in general income. Market confidence is shaky about investment and output. However, the government may resort to expansionist policy to restore growth. But, as discussed in Chapter 5, if the demand schedule is inelastic, the government intervention may further fuel inflation. Thus, inflation can cause output to fall more sharply under a situation of institutional rigidities and ill-timed expansionist policies in countries like India. Since the implications of inflation can be assigned to both supply and demand side effects, it is rational to examine its effects in a proper framework of fully specified regression for per capita real income growth. More specifically, in such a model, the question is whether inflation is a fundamental determinant of growth as are other variables such as investment, human capital, weather conditions and population growth. The same is attempted in the following section, which also examines the non-linear effects of inflation on growth in the case of India.

Inflation may affect economic growth through its effects on investment by affecting the real interest rate and investors' expectations about consumer confidence. Therefore, it is also important to examine the effects of inflation on investment and its determinants. Therefore, analysis of this aspect is done later in section 4.5 of this chapter.

4.4 INFLATION IN A GROWTH REGRESSION

Following the seminal work of Barro (1991), the recent empirical literature on economic growth (for example *inter alia* Levine and Renelt (1992), Sala-i-Martin (1997a; 1997b)) has identified a number of both supply and demand side variables that are partially correlated with the rate of economic growth. Variables like the initial level of income, the investment rate, various measures of education, population growth, terms of trade, and policy indicators like inflation, black market premium, fiscal surplus and many others have been found significant.

In order to identify variables to be included in the growth regression, it is proposed to build the empirical model as a regression analogue of growth accounting, which can facilitate identifying the mechanism through which macroeconomic variables like inflation affect economic growth. Consider the production function:

$$Y_t = F(K_t, L_t, H_t, A_t) \tag{4.7}$$

where Y is output, K is capital, L is labour, H is human capital and A can be considered to represent other variables that can affect output either independently or through its effect on the efficiency of the factors of production. In growth accounting literature A is generally known as factor efficiency. Differentiating (4.7) with respect to time and after dividing throughout by Y and rearranging, the growth accounting equation is obtained in the following form:

$$\dot{Y}/Y = \alpha_K(\dot{K}/K) + \alpha_L(\dot{L}/L) + \alpha_H(\dot{H}/H) + \alpha_A(\dot{A}/A) \tag{4.8}$$

where α_i is the share of factor payments in total product or the elasticity with respect to argument i in equation (4.7). Now, let the population growth of the economy proxy the growth rate of the available labour force. With this assumption, the equation for per capita economic growth can be written in the form of equation (4.9).

$$\Delta ypc = (\dot{Y}/Y - \dot{L}/L) = \alpha_K(\dot{K}/K) + (\alpha_L - 1)(\dot{L}/L) + \alpha_H(\dot{H}/H) + \alpha_A(\dot{A}/A) \tag{4.9}$$

As mentioned above, the last term in equation (4.9) can be considered to represent those variables that can affect the output growth either independently or through its effect on the efficiency of the factors of production. For a given change in capital stock, population growth and the change in human development, changes in the weather conditions and the price level can force per capita output growth to deviate from its potential path. As pointed out by Laidler and Parkin (1975), inflation also has income redistribution consequences. With inflation the purchasing power of the rupee deteriorates, which affects consumption patterns especially for the poor, leading to social tensions and adverse effects on economic growth as a fall-out. In an agriculture dominated economy, deviations of rainfall from normal can have important affects on economic growth by increasing productivity of agricultural assets and labour, which also feeds into the productivity of the industrial sector.[48]

[48] See Kalirajan and Sankar (2001) for a recent analysis of the role of agriculture sector in economic growth in India

Representing deviation of rainfall from normal with DRAIN and change in price level with INF, the effects of such variables on the economic growth can be written as follows.

$$\dot{A}/A = \phi_0 + \phi_1 DRAIN + \phi_2 INF \tag{4.10}$$

In developing countries like India, the government is involved in large-scale production activities, and the efficiency of investment is not the same as that of the private sector. Therefore, it can be rational to consider two types of mutually exclusive investments: first, the gross domestic investment in private sector (GDIZPV) and other in the public sector (GDIZPB), both taken as a fraction of gross domestic product (GDP). Further, following the earlier convention of representing the variables taken in logs with their lower case letters, while a Δ before the variable represents its first difference, the population growth can be written as Δpop. In the growth literature variables such as years of education and literacy rates have been used to proxy human capital. Therefore in this study, data on the literacy rate among total young adults as a fraction of the population aged above 15 years, is represented by LIT, and chosen to proxy human capital. Thus, replacing $\dot{H}$ with ΔLIT, $\dot{L}/L$ with Δpop, INF with Δp and $\dot{K}/Y$ with two types of investments GDIZPV and GDIZPB as defined in the above equations 4.9 and 4.10, after making some adjustments in the parameters, will yield the equivalent reduced form of real per capita growth equation (4.8) as presented below in equation 4.11.

$$\begin{aligned} \Delta ypc_t = \beta_0 + \beta_{PV}(GDIZPV)_t + \beta_{PB}(GDIZPB)_t + \beta_L(\Delta pop)_t + \beta_H(\Delta LIT)_t \\ + \beta_R DRAIN_t + \beta_{INF}\Delta p_t \end{aligned} \tag{4.11}$$

Where,

DRAIN	Deviation of rainfall index (June-Sep) from its 50-year average taken as fraction of the average.
GDIZPB	Gross domestic investment in public sector taken as fraction of gross domestic product at current market price (GDP)
GDIZPV	Gross domestic investment in private sector taken as fraction of GDP
LIT	Literacy rate among total young adult taken as fraction of people aged above 15 years
POP	Population in millions (mid year estimate)
P	Wholesale price index (WPI) of all commodities converted to base 1993-94
Y	Real gross domestic product (RGDP) at 1993-94 market prices (rupees millions)

YPC	Per Capita RGDP (rupees per person). YPC = Y/POP
Δp	Inflation in fractions. Δp=log(P/P(-1))
Δpop	Population growth. Δpop=log(POP/POP(-1))
ΔLIT	Change in literacy rate. ΔLIT=LIT-LIT(-1)
Δypc	Per capita real GDP growth. Δypc=log(YPC/YPC(-1))

Non-Linearity

Asymmetry between the relationship of inflation and growth has been highlighted in several studies (see Sarel (1996) for example), arguing that inflation has an adverse effect on economic growth only after it crosses a threshold limit, below which there is no negative effect on growth. Specifically the three questions to be addressed are: (1) is there any threshold level of inflation in the case of India above which inflation becomes detrimental? (2) Is such a structural break statistically significant? (3) What is the optimal level of inflation in the case of India? In order to examine such effects, equation 5.11 can be modified to include a dummy variable $PIDE_i$ defined as follows:

Let Δp^*= the rate of inflation at which the structural break occurs. Let a dummy variable be defined as DD = 1 if $\Delta p > \Delta p^*$, and DD = 0 otherwise. Then, a variable taking into account the extra inflation over Δp^* is defined as $PIDE_i$=DD*(Δp- Δp^*), where i symbolizes the value of Δp^*. For example, the variables $PIDE0.020$, $PIDE0.025$, and $PIDE0.200$ represent extra inflation at Δp^*= 0.020, 0.025, and 0.200, respectively. When the OLS regression is estimated with $PIDE_i$ and Δp as the regressors, the relevant estimators for contemporaneous inflation are as follows: When inflation is low ($\Delta p < \Delta p^*$), the $PIDE_i$= 0 by construction and the relevant estimator for inflation is Δp. However, when inflation is high ($\Delta p > \Delta p^*$), the relevant estimator is the sum of the two coefficients: the coefficient of Δp and $PIDE_i$. With a chosen basic model, the OLS regression is iterated with different $PIDE_i$ variables. This generates a series of regression statistics corresponding to different chosen values of Δp^*. The structural break occurs at the value of Δp^*, for which the R-Square value is the maximum. The coefficient of $PIDE_i$ shows the effect of inflation on growth when the former exceeds the threshold level and its standard error (or t-statistic) value tests whether or not the structural break is significant.

Estimation

A summary description of data is provided in Annexure 4.1 of this chapter, while further details like sources and derived data are given in Appendix AA of the thesis. Following the tradition of time series analysis, all variables are tested for their time series properties. The unit test results are presented in Annexure 4.2 of this chapter. DRAIN, ΔLIT, Δpop, Δypc, and Δp are all stationary while GDIZPV and GDIZPB are integrated of order one in the ADF based unit root test. Thus the data set of the explanatory variables contains variables, which are integrated of different orders, while the dependent variable is stationary. However, since one of the objectives of this analysis is to examine the long-term effects of these variables on growth, it is proposed to carefully estimate the equation with particular emphasis on the diagnostic properties of the residuals. As a preliminary check, all the variables taken together are found to be cointegrated in a test for cointegration following Johansen's method discussed in Appendix AB of this thesis. Therefore, the ordinary least squares estimation is expected to be consistent and free from the spurious regression. The basic equation is estimated in a distributed lag specification of the following form.

$$Y_t = \alpha + \sum_{i=1}^{m} A_i Y_{t-i} + \sum_{i=0}^{m} B_i X_{t-i} + \mu_t \tag{4.12}$$

Here α is a vector of constants, Y_t is $(n x 1)$ vector of endogenous variable, X_t is $(k x 1)$ vector of explanatory variables as, A_i and B_i are $(n x n)$ and $(n x k)$ matrices of coefficients, and μ_t is a stochastic error term. A preliminary experimentation with the data indicated that a lag of order one should be enough, which is reasonable for annual data.

From the general unrestricted estimate, the specific model is obtained by a downward specification search, as suggested by Hendry (1995) (see section AB.4, Appendix AB for a note on general to specific modeling). Both the unrestricted model YPC1 and the restricted model YPC2 are presented in Table 4.3. It may be noted that both have satisfactory statistical properties, free of problems such as serial correlation, and reasonably high R-square values. The long-run coefficients and their standard errors are also estimated using variance-covariance matrices and reported in Table 4.3 The sum of the coefficients of Δp and Δp(-1) in simple linear models YPC1 and YPC2 is not significantly other than zero. This means there is no long-term effect of inflation on growth in this linear model, while the short-run effect is significantly negative.

However, the possibility of non-linear effects of inflation on growth needs to be incorporated, using seventeen series of inflation dummy variables, $PIDE_i$, defined earlier, as follows:

$$\begin{aligned}\Delta ypc_t &= a_0 + a_1(GDIZPV)_t + a_2(GDIZPV)_{t-1} + a_3(GDIZPB)_t + a_4(GDIZPB)_{t-1} \\ &+ a_5(\Delta pop)_{t-1} + a_6(\Delta LIT)_{t-1} + a_7 DRAIN_t + a_8 DRAIN_{t-1} \\ &+ a_9\Delta p_t + a_{10}\Delta p_{t-1} + a_{11}PIDE_{it} + \mu_t\end{aligned} \tag{4.13}$$

In order to find the value of PIDE that provides the best non-linear model, the following procedure is adopted.

1. Profiles of R-bar squares, and the Logs of Likelihood function for the base model are plotted in Figures 4.2 and 4.3 to indicate what value of Δp^* maximizes the value of the base regression.
2. Size and significance level of the sum of coefficients of Δp and PIDE (a9 + a11) are plotted in Figure 4.4 to determine the contemporaneous effect of higher than Δp^* inflation on growth.
3. Size and significance level of the sum of coefficients of Δp, Δp (-1), and PIDE, (a9 + a10 + a11) are plotted in Figure 4.5 to determine the long-term effect of higher than Δp^* inflation on growth.

On examining Figures 4.2 and 4.3, where R-bar squares and logs of likelihood functions are plotted, the function is maximized for Δp^*=0.055. This also means the sum of the squared residuals from the regressions is minimized for Δp^*=0.055. Corresponding to this value of inflation, the regression results are presented in models YPC3 in Table 4.3. Model YPC3 explains 95 percent of economic growth in India and, at the same time, has very satisfactory statistical properties. For this particular model the sign of a9 + a11 is negative and significant as is clear from entries in the last row of Table 4.3. This means that effect of contemporaneous inflation on economic growth is significantly positive when the inflation rate is less than 5.5 percent, and its effect on economic growth is significantly negative when the inflation rate exceeds 5.5 percent.

Table 4.3 Regression results of per-capita real GDP growth: selected models (1972-1998)

	Unrestricted Model	Restricted Model	Restricted Model with non-linear inflation
Model Number	YPC1	YPC2	YPC3
Regressor/ Dependent variable	Δypc	Δypc	Δypc
Intercept	-0.07 (0.08)	-0.03 (0.05)	0.002 (0.04)
Real per capita output growth (Δypc) (-1)	0.08 (0.16)		
Deviation of rain from normal (DRAIN)	0.075 (0.03)**	0.09 (0.03)*	0.10 (0.02)*
Deviation of rain from normal (DRAIN)(-1)	-0.073 (0.03)**	-0.06 (0.03)**	-0.06 (0.02)*
Population growth (Δpop)	-1.03 (0.95)		
Population growth (Δpop) (-1)	-3.33 (1.19)**	-3.37 (1.19)**	-2.59 (0.89)*
Change in Literacy rate (ΔLIT)	7.48 (5.68)		
Change in Literacy rate (ΔLIT) (-1)	13.28 (5.09)**	9.96 (4.70)**	6.50 (3.55)***
Private investment to GDP (GDIZPV)	0.49 (0.19)**	0.51 (0.17)*	0.46 (0.13)*
Private investment to GDP (GDIZPV) (-1)	-0.30 (0.18)	-0.25 (0.17)	-0.41 (0.13)*
Public investment to GDP (GDIZPB)	-0.48 (0.40)	-0.37 (0.35)	-0.23 (0.26)
Public investment to GDP (GDIZPB) (-1)	0.41 (0.37)	0.50 (0.35)	0.18 (0.27)
Inflation (Δp)	-0.23 (0.06)*	-0.24 (0.06)*	0.34 (0.16)**
Inflation (Δp) (-1)	0.22 (0.06)*	0.19 (0.06)*	0.25 (0.05)*
Inflation Dummy PIDE0.055			-0.75 (0.19)*
R-Square	0.93	0.91	0.95
R-Bar-Square	0.85	0.85	0.92
S.E of Regression	0.012	0.012	0.009
F statistic, F (k-1, n-k), n=27, k= no. of regressors including intercept	12.72 [0.00]	15.48 [0.00]	27.76 [0.00]
Diagnostic Tests			
LM (1) serial correlation	0.84 [0.36]	0.08 [0.78]	0.88 [0.35]
LM (3) serial correlation	3.10 [0.38]	2.63 [0.45]	3.97 [0.35]
ARCH (3) test CHSQ (3)	0.22 [0.98]	0.96 [0.81]	1.95 [0.58]
Functional Form CHSQ (1)	1.53 [0.22]	0.01 [0.93]	1.96 [0.16]
Normality CHSQ (2)	1.54 [0.46]	0.71 [0.70]	0.49 [0.78]
Predictive failure CHSQ (6)	1.54 [0.96]	1.56 [0.96]	2.04 [0.92]
Residual Unit root			
Test statistics (DF)	-5.27	-4.87	-4.00
Long-term Coefficients			
Deviation of rain from normal	0.002 (0.05)	0.03 (0.05)	0.04 (0.03)
Population growth (Δpop)	-4.36 (1.52)*	-3.37 (1.19)*	-2.59 (0.89)*
Change in Literacy rate (ΔLIT)	20.77 (9.06)**	9.96 (4.70)**	6.50 (3.55)***
Private investment to GDP (GDIPVT)	0.19 (0.20)	0.26 (0.16)	0.06 (0.13)
Public investment to GDP (GDIPUB)	-0.07 (0.26)	0.13 (0.23)	-0.05 (0.17)
Inflation (Δp)	-0.007 (0.08)	-0.05 (0.07)	-0.16 (0.06)*
Contemporaneous Coefficients			
Sum of current inflation and dummy			-0.41 (0.06)*

Note: Predictive failure tests are conducted by breaking the sample at 1992. Unit root test statistics are presented corresponding to the SBC model selection criteria in a unit root test with second order ADF. *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

In order to analyze the long-term impact, the coefficients of lagged inflation also need to be taken into account. While comparing the positive impact of inflation in the current and previous periods with the negative impact of PIDE, the sum of their coefficients a9+a10+a11 is also negative and significant at one percent level. Thus, in the long run, economic growth is adversely affected by inflation when it exceeds the 5.5 percent level.

Figure 4.2 Log Likelihood of regression with base model YPC2

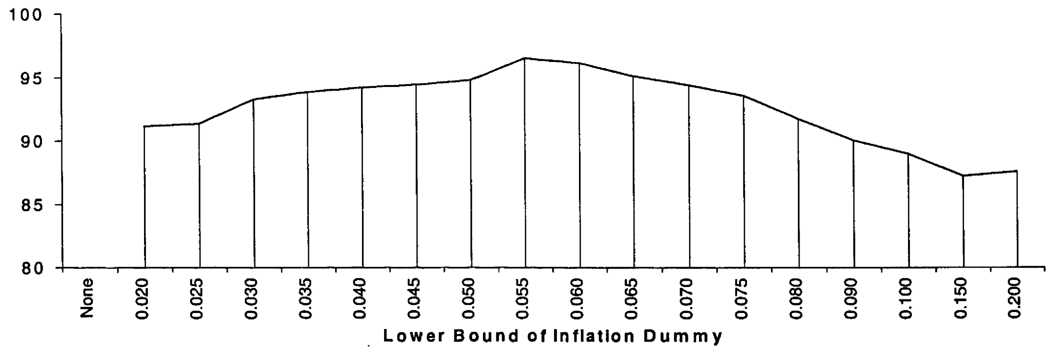


Figure 4.3 R-Bar- Square of regression with base model YPC2

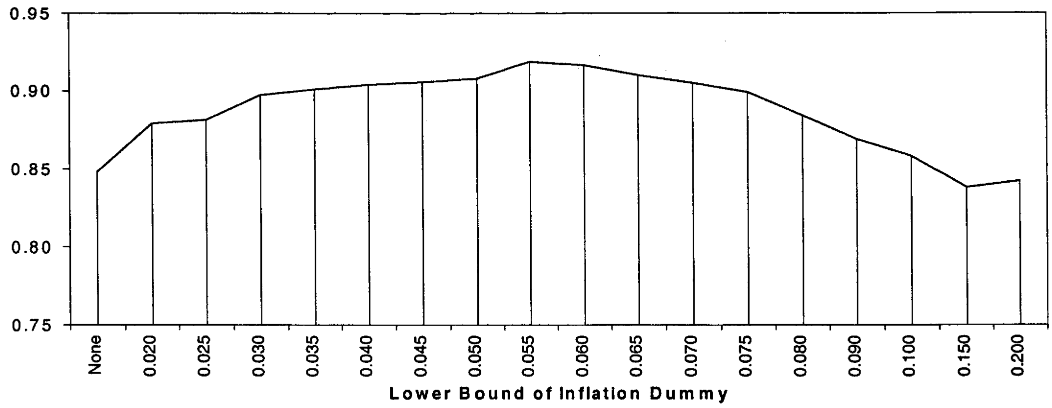


Figure 4.4 Contemporaneous non-linear effect of inflation on economic growth

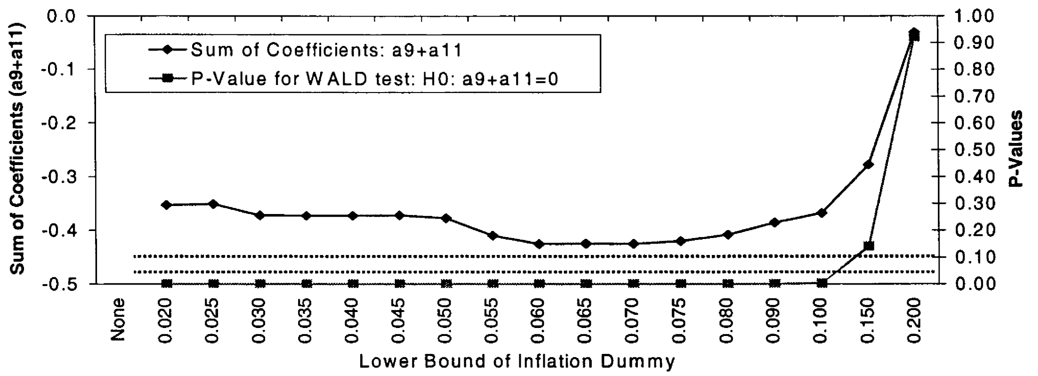
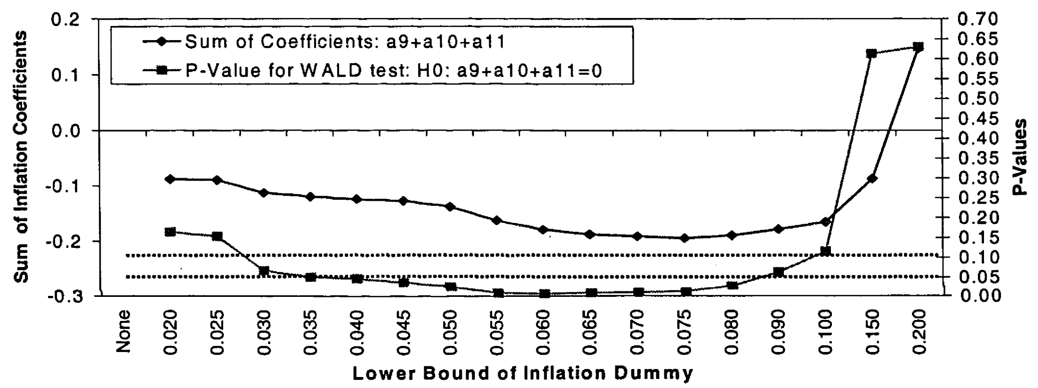


Figure 4.5 Long-run Non-Linear effect of inflation on economic growth



Further, it can be easily seen from Figures 4.4 and 4.5 that the size of the effect of inflation is fairly constant at a lower level of inflation of below 5.5 percent, while it increases for a higher level of inflation. Therefore, a lower level of inflation is desirable from the point of view of policy planning. The plots of the values of log-likelihood and R-bar-square for model YPC3, presented in Figures 4.2, and 4.3, indicate that these curves are quite flat from the left side, while a steeper slope can be seen from the right side. This also indicates that higher than 5.5 percent inflation must be avoided and lower than 5.5 percent inflation should be preferred.

The analysis in this section differs in several aspects from the earlier study of Kannan and Joshi (1998). First, the data series in this study is longer than that of Kannan and Joshi. Second, their analysis is based on a static model, which is generally not appropriate for examining the impact of inflation in India. Third, in the process of their identification of the threshold level of inflation, the statistical tests they used produce two different results. Briefly, their R-square was the maximum for a 7 percent inflation level. However, the result of their encompassing tests between the 6 and 7 percent specification revealed no significant difference. This may necessitate doing encompassing tests between the different rates of inflation, which they did not carry out. When an encompassing test between the 5.5 percent inflation rate and different rate below and above 5.5 percent was carried out in this study, the 5.5 percent rate consistently identified as the best goodness of fit indicating the structural break (see Table 4.4).

Finally, in Kannan and Joshi's (1998) study, the sum of the coefficient of inflation and the variable 'extra' (equivalent to variable PIDE in this study), which indicates the effect of inflation on economic growth when the former exceeded the threshold level, appears to be insignificant. This raises overall doubt about their conclusions.

Table 4.4: Alternative test for non-nested regression models

Model M1 Model YPC2 with $PIDE_i$	Model M2 Model YPC2 with $PIDE_i$	Akaike's Information Criterion of M1 versus M2 favours:	Schwartz's Bayesian Criterion of M1 versus M2 favours:
PIDE0.055	PIDE0.020	M1	M1
PIDE0.055	PIDE0.025	M1	M1
PIDE0.055	PIDE0.030	M1	M1
PIDE0.055	PIDE0.035	M1	M1
PIDE0.055	PIDE0.040	M1	M1
PIDE0.055	PIDE0.045	M1	M1
PIDE0.055	PIDE0.050	M1	M1
PIDE0.055	PIDE0.060	M1	M1
PIDE0.055	PIDE0.065	M1	M1
PIDE0.055	PIDE0.070	M1	M1
PIDE0.055	PIDE0.075	M1	M1
PIDE0.055	PIDE0.080	M1	M1
PIDE0.055	PIDE0.090	M1	M1
PIDE0.055	PIDE0.100	M1	M1
PIDE0.055	PIDE0.150	M1	M1
PIDE0.055	PIDE0.200	M1	M1

The results from model YPC3 in Table 4.3 show the following additional information for the Indian economy. First, private sector investment has a significant positive effect on growth in the short-run; the long-term effect is also positive but not significant. Public sector investment does not appear to have a significant effect, either in the short or long run, most probably because of the prevailing inefficiencies in the majority of public sector enterprises in India (see for example Sankar (1992)). The policy implication of this result favours more involvement for the private sector in the Indian economy.

Second, the coefficient of population growth is significantly negative. This supports the well-known proposition that high population growth is in fact detrimental to growth in the long run, at least in developing countries like India, as it puts pressure on resources.

Third, it can be noticed that change in the literacy rate has a significantly positive coefficient. There is a large literature that advocates the development of human capital as an important factor in the growth process. The literacy rate in India amongst individuals aged 15 years and above has grown from about 33 percent in 1970-71 to about 58 percent in 1998-99. While not a particularly impressive performance, this still had a very significant effect on growth. Possibly realizing the importance of these factors, the Indian government now (2000-2001) appears to be increasing the participation of private agents in the core sector of the economy through second-generation reforms, which would allow state efforts to be directed towards improving literacy, health care and infrastructure development.

Finally, the significance of the coefficient of DRAIN implies that agriculture growth, which improves with better rain conditions, is an important factor contributing to overall economic growth, at least in the short run.

The important result is that the threshold level of inflation appears to be 5.5 percent. When inflation exceeds this level, economic growth is significantly adversely affected. An increase in inflation by one percentage points above this level will result in a fall in economic growth by 0.16 percentage points in the long run and 0.41 percentage points in the short-run. It may thus be concluded that India cannot tolerate inflation above 5.5 percent, which is close to the figure of 6 percent the former Governor of the RBI, Dr Rangarajan (1998a, 2001) has been suggesting.

4.4 EFFECTS OF INFLATION THROUGH SAVINGS AND INVESTMENT

The foregoing discussion has shown the positive effects of private sector investment on growth, in line with theoretical expectations. However, as pointed out earlier, investment itself can be an important channel of transmission for the indirect effects of inflation. Therefore, it is important to examine this issue.

Investment and national savings rates are highly positively correlated in virtually all countries (Baxter and Crucini 1993). This is puzzling for developed countries, as it apparently implies a low degree of international capital mobility. [49] On the other hand, for countries like India where international capital flows are known to be restricted, such a relationship should not be a puzzle. Most aggregate investment in India (more than 90 percent) comes from domestic savings. Therefore, the analysis of savings behaviour and the effects of inflation on savings are important for the analysis of investment. It may be recalled that investment in the growth models distinguished between private and public sector investment. While private sector investment has a significant positive effect on growth, public sector investment has an insignificant effect. Further, public sector investment can be considered more like an exogenous variable in the Indian context, where such investments have a lot of political and welfare overtones rather than profitability considerations. Therefore, the analysis in this section, focuses on private sector investment (GDIZPV) and gross national savings (GNSZ)[50], both expressed as a fraction of gross domestic product.

Another important aspect of the Indian economy is that household saving forms more than 70 percent (and up to 80 percent during some periods) of total savings. The theoretical literature on aggregate consumption and savings behaviour is not unanimous regarding determinants. Some consumption is accounted for by life-cycle-permanent-income consumers, and some by simple Keynesian consumers. This is partly due to liquidity constraints and evidence to support the existence of buffer-stock saving (Dornbusch and Fischer 1994:316). For a developing country like India, three major considerations for savings can be identified in simple terms. First, in the absence of state social security, individuals are concerned with future survival. Second, the social order requires bulk spending on occasions like the marriage of

[49] In economic literature this is known as the 'Feldstein Horioka Puzzle' after their famous paper on domestic saving and international capital mobility (Feldstein and Horioka 1980)

[50] Some earlier studies on savings in India (for example Athukorala and Sen (2001) and Muhleisen (1997)), which focus more on the components of savings, have criticized the data compilation procedure on savings in India. Muhleisen (1997) has even generated his own series of different components. However, since the purpose of the present analysis is to examine the effect of inflation on overall savings at aggregate level, the aggregate data on national savings is taken from The World Bank CDROM-2000, where the gross national savings is calculated by subtracting total consumption expenditure from the gross domestic product and adding net income and net current transfers from abroad. Therefore, in a way the analysis of savings is also an analysis of consumption behaviour. Full detail of data sources is provided in Appendix AA of this thesis.

children and several other religious ceremonies and people feel gratified by such expenditure. Thirdly, there is a strong desire to leave a bequest for children and spouse. Therefore, most individuals keep their own needs to a minimum and maintain a savings target.

In such a situation, saving is likely to increase in proportional terms with any increase in permanent or current income. Savers receive return in the form of interest or dividend and capital gains on stocks. Therefore, saving is also expected to increase[51] if interests on deposits are more and government provides incentives in the form of infrastructure like institutional expansion and tax relief on savings.

However, savings behaviour becomes distorted in the presence of inflation. It may be cut short to meet already minimized physical consumption or small savers may become biased towards leveraged investments in tangible assets, especially real assets, like jewelry and consumer durables. Kane (1980) argues that, in the presence of deposit rate ceilings, accelerating inflation simply victimizes small savers who are disadvantaged in access to credit. On the other hand, if individuals are faced with economic uncertainty, they are expected to save more as predicted by the literature on precautionary savings. Athukorala and Sen (2001) proxy such economic uncertainty with inflation and argue that inflation may cause savings to rise. Therefore, it is important to understand the relationship between inflation and savings in order to appreciate the full effects of inflation on investment.

Drawing on the literature (see for example Athukorala (1998); Joshi and Little (1994); Frenkel and Razin (1994); Krishnamurty, et al. (1987); Davidson (1986); McKinnon (1973); Shaw (1973)) on savings, investment and development, and on the foregoing discussion, the following reduced form functions are considered appropriate for analyzing the effect of inflation on economic growth through an investment channel.

$$\underset{}{GDIZPV} = f(\underset{-}{RLRSBI}, \underset{+}{GNSZ}, \underset{-/+}{CGAPZ}) \tag{4.14}$$

$$GNSZ = f(\underset{+}{yp}, \underset{+}{DR1}, \underset{-}{\Delta p}, \underset{-}{UTID}, \underset{+/-}{TOT}, \underset{-}{CBDN}) \tag{4.15}$$

[51] It may be noted that when saving is considered only as a means to finance retirement, it is likely that less saving would be required with an increased interest rate. Therefore, some economists believe that interest rates should either reduce savings or they cannot have any effect.

Here, GNSZ, GDIZPV, and Δp are the same as defined earlier. The other new variables are described as follows: RLRSBI is the real interest rate on lending by the state bank of India (SBI) calculated by subtracting the current annual inflation from the nominal lending rate (LRSBI). With increasing lending rates investment is expected to fall.

CGAPZ is the gap between combined total outlay and combined total current revenue of central and state governments as a percentage of GDP and is a proxy for the fiscal deficit. In the development literature, government spending on development projects has been considered to play an important role in boosting private investment (Bardhan 1984). However, excess government spending also leads to higher fiscal deficits, which is considered inflationary (Catao and Terronesi 2001) and an indicator of poor fundamentals from the point of view of private investor confidence. With an increasing fiscal deficit, it is also expected that resource allocation will become distorted and the private sector may find credit costly, causing private sector investment to fall. Yet a substantial portion of the deficit may be argued to arise from government expenditure on development projects, including in the agricultural sector, which has a stimulating effect on private investment. Therefore, it is preferred to use overall government deficit in the investment equation rather than expenditure alone. However, in view of the possibilities of mixed effects, the sign of CGAPZ is an empirical matter. The role of fiscal deficit in the creation of money and hence inflation will be discussed later in Chapter 7.

yp is the log of permanent income calculated from real GDP using the error-learning hypothesis of Laidler (1985:88) with a geometric weight of 0.5 for the current year and the remaining geometric weights distributed over the previous 10 years (see Appendix AA of this thesis for more details). An increase in permanent income is expected to increase savings and hence investment. DR1 is the interest rate paid by commercial banks on 1-3 year deposits. With an increase in deposit rates, the time deposits in commercial banks are expected to increase. At the same time, this may erode profitability of the banking sector in the presence of institutional rigidity and controls on lending rates, a point raised in Chapter 1.

UTID is the dividend paid by Unit Trust of India (UTI)[52], which is a proxy for the loss of financial savings, particularly of the public sector (a higher dividend would have a negative effect on national savings) but it also provides an incentive for small savers in mutual funds, which may increase investment. TOT is terms of trade expressed in terms of ratio of unit value index of export (UVIE) to unit value index of imports (UVII). TOT is expected to have a positive correlation with both gross domestic product (GDP) and gross national savings (GNS). However, the effect of TOT on GNSZ may be positive or negative depending on the relative magnitude of its effect on GDP and GNS. CBDN is commercial bank density in the country measured as thousands of people per branch; it is expected that a fall in bank density would mean more banking facility for small saver in time deposit.

In order to capture the overall effects of direct and indirect variables on private investment, equations 5.14 and 5.15 can be written in reduced form as follows, where the real lending rate (RLRSBI) is now replaced with the nominal lending rate (LRSBI) and inflation, so that the overall effect of inflation on private investment can be measured in a straight forward way.

$$GDIZPV = f(LRSBI, CGAPZ, yp, DR1, \Delta p, UTID, TOT, CBDN) \qquad (4.16)$$

A summary of data is presented in Annexure 4.1 of this chapter. More details on data like sources and constructed data are provided in Appendix AA of the thesis. Again, all variables are tested for the unit root using the ADF method and test results are presented in Annexure 4.2. The key variables do not have the same order of integration. Particularly, GNSZ, Δp, yp, and CBDN are stationary when tested with intercept and no trend, while GDIZPV, LRSBI, CGAPZ, UTID, DR1, and TOT are integrated of order one. After taking the first difference, all the variables are stationary. However, in modeling savings and investment, it is important to capture some of the long-run relationships along with the short-run behaviour of the explanatory variables. This calls for modeling in the error correction framework.

Initial attempts to model through the cointegrating vector error correction modeling (VECM) approach failed to provide clear identification of the long-term relationships due to the presence of several stationary variables which resulted in

[52] UTI is the largest mutual fund in India

several cointegrating vectors. However, the alternative method of the single equation restricted error correction modeling (RECM) procedure of Hendry (1995), which allows the model to include lagged dependent and independent variables along with the terms of difference, proved to be more flexible (see section AB.4, Appendix AB for a note on general to specific modeling). A careful estimation with respect to the diagnostic properties of the residuals will guard against any spurious content. For this purpose the distributed lag model presented in equation 4.12 can be rearranged in terms of differences and lagged levels in the following unrestricted error correction form as follows.

$$\Delta Y_t = \alpha + \sum_{i=1}^{m-1} A_i^* \Delta Y_{t-i} + \sum_{i=0}^{m-1} B_i^* \Delta X_{t-i} + C_0 Y_{t-m} + C_1 X_{t-m} + \mu_t \tag{4.17}$$

where $C_0 = -\left(I - \sum_{i=1}^{m} A_i \right)$, $C_1 = \left(\sum_{i=0}^{m} B_i \right)$ and $C_0^{-1} C_1$ represents the long-run multiplier for the system. Considering equation (4.17) as the 'maintained hypothesis' of the specification search, the general model is 'tested down' by the ordinary least square regression starting with adequate lags permitted by the sample size. The insignificant lagged terms are dropped systematically until a statistically acceptable model in a priory theoretical framework is obtained. The estimated reduced form model for private investment is presented in Table 4.5. The model is tested for possible unit root in the residuals, using the ADF method and the results are presented[53]. The diagnostic tests indicate that the model is statistically satisfactory and acceptable. The CUSUM test and the CUSUM-square test on the recursive residuals (not presented here) did not indicate any sign of structural breaks. The R-square and the R-bar square for the model are 0.90 and 0.76, which is high enough for reasonable predictions. The long-term relationship of GDIZPV with other variables is reproduced at the bottom of Table 4.5 with standard errors of coefficients estimated using variance–covariance matrix.

[53] Considering the fact that the sample size is small, test statistics for unit root test applicable for multivariable case may not be reliably obtained from standard tables. However, considering the unit root test on residual as a single variable case, the 95 percent critical value is –3.00 for the present sample size, which shows that the test statistic is satisfactory.

In the context of the subject matter of this chapter, the important conclusion emerging from this estimation is that inflation is not a significant determinant of private investment per se, either in the long or the short run. The above finding leads to a conclusion that inflation does not exert any indirect influence on economic growth through private investment.

Table 4.5 Estimated model of gross domestic investment in private sector as fraction of gross domestic product (1972-97)

Model: GDIZPV

$$\Delta GDIZPV = \underset{(0.337)}{-0.882^{**}} - \underset{(0.179)}{0.948}\, GDIZPV(-1)^{*} - \underset{(0.293)}{1.060}\, LRSBI(-1)^{*} + \underset{(0.288)}{0.683}\, CGAPZ(-1)^{**}$$

$$+ \underset{(0.024)}{0.084}\, yp(-1)^{*} - \underset{(0.426)}{0.934}\, DR1(-1)^{**} + \underset{(0.060)}{0.085}\, \Delta p(-1) + \underset{(0.174)}{0.405}\, UTID(-1)^{**}$$

$$- \underset{(0.057)}{0.215}\, TOT(-1)^{*} - \underset{(0.300)}{0.556}\, \Delta LRSBI^{***} + \underset{(0.216)}{0.228}\, \Delta yp - \underset{(0.391)}{0.581}\, \Delta DR1 + \underset{(0.052)}{0.076}\, \Delta(\Delta p)$$

$$- \underset{(0.176)}{0.540}\, \Delta UTID - \underset{(0.037)}{0.090}\, \Delta TOT$$

R-square = 0.90, R-bar-square = 0.76. SE of regression = 0.0087, F-Statistic F (14, 11) = 6.71[0.002]. DW statistics = 1.86. LM serial correlation CHSQ (1) = 0.226 [0.63], LM serial correlation CHSQ (3) = 2.125 [0.55]. Heteroscedasticity CHSQ (1) = 2.684 [0.10], ARCH (3) CHSQ (3) = 1.15 [0.76]. Functional form RESET CHSQ (1) = 0.015 [0.90]. Normality CHSQ (2) = 2.020 [0.36]. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 4.36. Predictive failure test (Chow's second test) after breaking the sample at 1992 CHSQ (5) = 1.37 [0.93].

*significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

<u>**Long term coefficients of private investment**</u>

$$GDIZPV = constant - \underset{(0.415)}{1.118}\, LRSBI^{*} + \underset{(0.384)}{0.721}\, CGAPZ^{**} + \underset{(0.023)}{0.088}\, yp^{*} - \underset{(0.525)}{0.990}\, DR1^{***}$$

$$+ \underset{(0.066)}{0.089}\, \Delta p + \underset{(0.221)}{0.427}\, UTID^{***} - \underset{(0.081)}{0.227}\, TOT^{**}$$

Other important conclusions that can be drawn from the results in Table 4.5 are as follows. Nominal interest rates on lending as well as saving deposits tend to decrease private investment[54]. It may be pointed out that high deposit rates may lead

[54] However, in the context of interest rate liberalization and directed credit, Ahluwalia (1999) argues that it is the timely availability of credit, which matters more than the interest rate.

to high lending rates, particularly in the face of likely inefficiency of the banking and the financial institutions, most of which are in the public sector in India. The coefficients of nominal interest rates and inflation do not appear to suggest that there is significant consideration of the real interest rate by investors in India. This may be due to the fact that inflation in India was still generally less than two digit levels during the sample period.

A significant positive sign of combined fiscal deficit in the long-run shows that a one percentage point increase in the combined deficit leads to an increase in private investment to the extent of about 0.72 percentage points in the long-term. This indicates that significant government spending is directed towards development activities and motivating the private sector. In this context, it can be argued that government spending on infrastructure, such as railways, roads, communication and subsidies like manufacturing fertilizers, motivate the private sector to increase investment. While fiscal deficit appears to positively affect private investment, its overall positive effect on economic growth through investment may be significantly less than its negative effect through inflation itself, which is discussed in Chapter 7 on money supply.

As expected, growth in permanent real income has a favourable effect on savings and investment. The terms of trade has a negative sign, which shows that the effect of improvement in the terms of trade is more in increasing consumption than savings and investment. Similarly, the increases in UTI dividends motivates saving and hence investment in the long term, but in the short-run it appears to increase consumption rather than re-investment. The change in bank density CBDN is not found to add to the explanatory power of this model, although it has been found significant in explaining savings in some studies such as Athukorala (1998).

4.5 CONCLUSION

In this chapter, the effect of inflation on economic growth has been systematically analyzed from different perspectives.

In an interesting survey, Shiller (1996) poses the question "why do people dislike inflation?" In the Indian context, there could be several answers to this question. The important result is that inflation directly affects economic growth. Inflation is also inequitable because it hits poor people the most. The government can draw some benefits by way of collecting an inflation tax but that tax may not help the large mass of people in India living below the poverty line. On the contrary, increasing the purchasing power of the rupee by reducing inflation would directly help them more.

The results show that the threshold level of inflation for India is around 5½ percent, which was more or less the average inflation rate of its major trading partners during the sample period of 1971-98. Thus, India should be cautious that inflation should not exceed 5½ percent. It is found in this thesis that every percentage point increase in inflation over 5½ percent causes per capita output growth to fall by about 0.16 percentage points in the long run, which is a significant impact. Therefore, Indian policy makers should not be satisfied with containing inflation just below the two digits level. What can be inferred is that India should aim to keep inflation at least on par with the average rate of its trading partners, which is about the threshold level of 5½ percent. The results also show that inflation does not exert any significant indirect effect on economic growth through investment. Further, while the nominal interest rate on lending as well as deposits appear to decrease private investment, the fiscal deficit seems to exert positive influence on private investment.

Annexure 4.1 Summary description of data used in Chapter 4

Symbol	Variable description and unit of measurement
CBDN	Bank density: population (thousands) per branch of commercial bank.
CGAPZ	Fiscal Deficit: Combined gap between Total Outlay and Current Revenue divided by gross domestic product.
DR1	1-3 Year commercial banks average annual deposit rates taken in fraction.
DRAIN	Deviation of rainfall index (June-Sep) from its 50-year average taken as fraction of the average.
GDIZPB	Gross domestic investment in public sector taken as fraction of GDP
GDIZPV	Gross domestic investment in private sector taken as fraction of GDP
GDP	GDP at market prices at current prices (rupees million)
GNS	Gross national savings, including NCTR at current prices (rupees million)
GNSZ	Gross national savings taken as fraction of GDP. GNS = GNS/GDP
LIT	Literacy rate among total young adult taken as fraction of people aged above 15 years
LRSBI	Average annual lending rate of State Bank of India (SBI) taken in fraction.
P	Wholesale price index (WPI) of all commodities converted to base 1993-94 =100
POP	Population in millions (mid year estimate)
RLRSBI	Average real annual lending rate of state bank of India taken in fraction. RLRSBI = LRSBI – Δp
TOT	Terms of Trade (unit value of export (UVIE) as ratio of unit value of imports (UVII). TOT = (UVIE/UVII)
UTID	Unit Trust of India (UTI) annual Dividend Rate taken in fraction.
Y	Gross domestic product at constant (1993-94) market prices (rupees millions)
YPC	Per Capita GDP at constant market prices (rupees per person). YPC = Y/POP
YP	Permanent real income calculated from real GDP at factor cost according to the error-learning hypothesis discussed in Ladler (1989:88) with weight of 0.5 for current year and remaining geometric weights distributed over previous 10 years.

Annexure 4.2 Unit root test for variables used in Chapter 4 in levels and first differences

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
CBDN	DF	-2.980	-6.68	-31.01	-32.26	-3.594	-2.01	-30.35	-32.24
	ADF (1)		-3.58	-31.67	-33.56		-1.92	-31.35	-33.07
ΔCBDN	DF	-2.985	-3.13	-34.06	-35.28	-3.60	-5.02	-29.70	-31.53
	ADF (1)		-2.60	-34.42	-36.25		-4.50	-29.86	-32.30
CGAPZ	DF	-2.980	-1.47	81.63	80.37	-3.594	-1.80	81.27	79.38
	ADF (1)		-1.18	81.71	79.82		-1.21	80.91	78.40
ΔCGAPZ	DF	-2.985	-7.24	80.43	79.21	-3.603	-7.47	80.42	78.59
	ADF (1)		-3.95	79.43	77.61		-4.23	79.46	77.02
DR1	DF	-2.980	-1.71	85.73	84.48	-3.59	-2.99	87.77	85.89
	ADF (1)		-1.75	84.88	82.99		-4.74	91.64	89.12
	ADF (2)		-1.16	87.12	84.60		-3.18	90.67	87.53
ΔDR1	DF	-2.985	-4.55	80.47	79.25	-3.587	-4.55	79.78	77.95
	ADF (1)		-5.72	83.52	81.70		-5.70	82.91	80.47
	ADF (2)		-4.71	83.93	81.49		-4.61	83.22	80.18
DRAIN	DF	-2.975	-7.32	19.68	18.42	-3.587	-7.51	19.57	17.68
	ADF (1)		-3.74	18.77	16.88		-3.95	18.57	16.06
GDIZPB	DF	-2.980	-1.64	82.75	81.49	-3.594	-1.98	83.71	81.82
	ADF (1)		-1.23	82.00	80.11		-1.36	83.76	81.25
	ADF (2)		-0.80	82.19	79.67		-0.50	89.22	86.07
ΔGDIZPB	DF	-2.985	-6.21	78.57	77.35	-3.603	-7.00	79.91	78.08
	ADF (1)		-5.44	79.33	77.50		-8.38	86.04	83.60
	ADF (2)		-2.37	80.26	77.82		-4.63	85.42	82.37
GDIZPV	DF	-2.980	-2.50	69.26	68.00	-3.594	-4.57	73.66	71.77
	ADF (1)		-1.33	70.48	68.59		-2.93	72.80	70.28
	ADF (2)		-0.95	70.08	67.56		-2.44	71.80	68.65
ΔGDIZPV	DF	-2.985	-8.54	67.27	66.06	-3.603	-8.35	66.28	64.45
	ADF (1)		-5.49	67.29	65.46		-5.36	66.29	63.85
	ADF (2)		-3.71	66.51	64.08		-3.54	65.53	62.48
GNS	DF	-2.980	-3.52	79.52	78.26	-3.594	-3.94	80.09	78.21
	ADF (1)		-3.12	78.66	76.78		-3.44	79.11	76.60
	ADF (2)		-3.02	79.15	76.63		-2.85	78.85	75.71
ΔGNS	DF	-2.985	-6.24	71.74	70.52	-3.603	-6.22	71.06	69.23
	ADF (1)		-5.37	72.39	70.56		-5.50	72.09	69.65
	ADF (2)		-2.94	71.60	69.16		-3.10	71.20	68.15
LIT	DF	-2.980	-0.35	155.08	153.82	-3.594	-1.72	155.64	153.76
	ADF (1)		-0.40	155.09	153.21		-1.24	154.96	152.45
	ADF (2)		-0.40	154.10	151.59		-1.29	154.09	150.94
ΔLIT	DF	-2.985	-6.35	149.47	148.25	-3.603	-6.26	148.61	146.78
	ADF (1)		-3.74	148.47	146.64		-3.70	147.61	145.17
LRSBI	DF	-2.98	-2.62	73.36	72.11	-3.59	-1.39	72.98	71.09
	ADF (1)		-2.57	72.38	70.49		-1.09	72.09	69.58
	ADF (2)		-2.53	71.53	69.01		-0.51	72.14	68.99
ΔLRSBI	DF	-2.99	-4.62	66.84	65.62	-3.60	-5.88	69.50	67.67
	ADF (1)		-3.45	65.94	64.11		-5.27	70.18	67.74
	ADF (2)		-2.39	64.95	62.51		-4.78	70.70	67.65
p	DF	-2.980	-1.05	38.18	36.92	-3.594	-3.20	41.70	39.82
	ADF (1)		-0.92	37.90	36.01		-4.93	46.33	43.82
	ADF (2)		-0.93	38.80	36.28		-4.28	45.75	42.61

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
Δp	DF	-2.985	-4.10	38.41	37.19	-3.603	-3.97	37.41	35.58
	ADF (1)		-4.43	39.00	37.17		-4.29	38.01	35.57
	ADF (2)		-3.57	38.16	35.73		-3.47	37.18	34.14
pop	DF	-2.980	-2.58	116.48	115.22	-3.95	-0.22	115.49	113.61
	ADF (1)		-2.63	115.76	113.88		0.04	114.77	112.26
Δpop	DF	-2.985	-4.29	108.46	107.24	-3.603	-5.48	110.94	109.11
	ADF (1)		-2.54	107.54	105.71		-3.83	110.16	107.72
TOT	DF	-2.985	-2.07	21.54	20.33	-3.603	-4.28	27.23	25.40
	ADF (1)		-2.36	21.31	19.48		-4.66	27.53	25.09
	ADF (2)		-1.73	20.53	18.09		-3.84	26.59	23.55
ΔTOT	DF	-2.991	-4.16	19.46	18.28	-3.612	-4.26	18.97	17.20
	ADF (1)		-4.11	19.52	17.75		-4.40	19.55	17.20
	ADF (2)		-4.34	20.15	17.79		-5.23	21.90	18.96
UTID	DF	-2.985	-1.01	64.64	63.42	-3.603	-1.42	64.34	62.51
	ADF (1)		-1.12	64.33	62.50		-2.27	65.48	63.04
	ADF (2)		-1.12	63.36	60.92		-2.96	66.30	63.25
ΔUTID	DF	-2.991	-3.81	61.52	60.34	-3.612	-3.79	60.68	58.91
	ADF (1)		-2.86	60.52	58.75		-2.85	59.68	57.32
yp	DF	-2.980	3.31	71.96	70.70	-3.594	-1.03	71.99	70.11
	ADF (1)		2.34	71.01	69.12		-1.04	71.06	68.54
Δyp	DF	-2.985	-3.46	66.12	64.90	-3.603	-4.52	68.09	66.26
	ADF (1)		-2.69	65.22	63.40		-3.92	67.61	65.17
ypc	DF	-2.980	1.31	53.17	51.92	-3.594	-1.80	54.48	52.59
	ADF (1)		1.57	52.65	50.76		-1.57	53.74	51.22
Δypc	DF	-2.985	-5.38	50.10	48.89	-3.603	-5.92	50.81	48.98
	ADF (1)		-3.62	49.12	47.29		-4.27	50.12	47.68
	ADF (2)		-2.86	48.17	45.73		-3.59	49.39	46.35

Note: ADF = Augmented Dickey Fuller. AIC = Akaike Information Criterion. SBC = Schwarz Bayesian Criterion of model selection. The order of ADF test is chosen as two in all the cases. Numbers of observations vary from 23 to 26.

Annexure 4.3 Estimated equations used in determination of causal relationship of precedence in 'block Granger non-causality' test (1971-98)

	VAR-1		VAR-2		VAR-3		VAR-4	
Dependent Variable	Δypc	Δp	Δypc	Δp	Δypc	Δp	Δypc	Δp
Regressor								
Intercept	0.004 (0.01)	0.093* (0.02)	-0.003 (0.021)	0.123* (0.34)	-0.031 (0.03)	0.128** (0.05)	-0.02 (0.03)	0.14* (0.04)
Δp (-1)	0.229*** (0.13)	0.076 (0.20)	0.286*** (0.153)	0.087 (0.249)	0.388** (0.166)	0.088 (0.28)	0.46* (0.16)	-0.05 (0.20)
Δp (-2)			-0.036 (0.141)	-0.300 (0.230)	-0.12 (0.175)	-0.266 (0.30)	-0.14 (0.19)	-0.38 (0.24)
Δp (-3)					0.28*** (0.15)	-0.171 (0.25)	0.16 (0.17)	0.18 (0.22)
Δp (-4)							0.14 (0.15)	-0.54* (0.19)
Δypc (-1)	0.165 (0.21)	-0.673** (0.33)	0.175 (0.244)	-0.505 (0.397)	0.246 (0.272)	-0.364 (0.462)	0.23 (0.27)	-0.14 (0.34)
Δypc (-2)			0.238 (0.272)	-0.383 (0.362)	0.093 (0.248)	-0.194 (0.422)	0.04 (0.25)	-0.21 (0.32)
Δypc (-3)					0.233 (0.225)	-0.201 (0.383)	0.004 (0.23)	0.38 (0.20)
Δypc (-4)							-0.14 (0.21)	0.13 (0.27)
R-Square	0.12	0.20	0.15	0.28	0.28	0.23	0.47	0.56
LM (1) serial correlation	0.39 [0.53]	0.13 [0.58]	0.17 [0.68]	0.73 [0.39]	1.18 [0.28]	11.3 [0.00]	1.76 [0.18]	3.19 [0.07]

Note: *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Annexure 4.4 Estimated equations used in determination of causal relationship of precedence in Sims test of forecasting ability (1971-98)

	One lag System		Two lag system		Three lag system	
Dependent Variable	Δypc	Δp	Δypc	Δp	Δypc	Δp
Repressor						
Intercept	0.049** (0.02)	0.083* (0.02)	0.052** (0.026)	0.110* (0.026)	0.025 (0.038)	0.080** (0.035)
Δp	-0.308** (0.11)		-0.351* (0.119)		-0.353* (0.119)	
Δp (-1)	0.204*** (0.12)	0.260 (0.17)	0.289** (0.136)	0.360*** (0.202)	0.391** (0.167)	0.424*** (0.227)
Δp (-2)			-0.158 (0.124)	-0.423* (0.170)	-0.204 (0.160)	-0.377*** (0.210)
Δp (-3)					0.172 (0.177)	-0.033 (0.200)
Δypc		-0.839* (0.27)		-0.913* (0.271)		-0.836* (0.289)
Δypc (-1)	-0.116 (0.20)	-0.571** (0.28)	-0.031 (0.212)	-0.310 (0.318)	0.107 (0.242)	-0.100 (0.329)
Δypc (-2)			0.068 (0.193)	-0.255 (0.378)	0.041 (0.228)	-0.073 (0.808)
Δypc (-3)					0.146 (0.477)	0.121 (0.671)
Δypc (+1)		0.500*** (0.27)]		0.600** (0.257)		0.787* (0.268)
Δp (+1)	-0.142 (0.11)]		-0.091 (0.116)		-0.082 (0.681)	
R-Square	0.44	0.52	0.52	0.65	0.56	0.69
LM (1) serial correlation	0.66[0.42]	0.79[0.38]	2.41[0.13]	0.66[0.42]	2.02[0.16]	3.29[0.03]

Note: *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Chapter 5

The Inflation Process in India

5.1 INTRODUCTION

Chapter 4 established a strong case that inflation needs to be controlled in India, at least whenever it has a tendency to breach the 5.5 percent level. In order to identify the role of monetary policy in targeting inflation, it is important to understand and model the inflation process.

Identification of the inflation process requires examination of the determinants of economy wide aggregate demand and supply. There are different ways of specifying the aggregate supply and demand functions in the literature in order to deal with the problem of identification during estimation. The supply function in this chapter has been specified in terms of output gap and the demand function is specified following Romers's (2000) suggestion, which emphasizes a downward sloping aggregate demand curve in the inflation output plane. Due to several unknown shift parameters, the supply schedule is complex to specify. The implication of such unknown parameters can be captured in relationship between inflation and output gap. The output gap is treated in the literature, as one of the most important economic variables for theoretical as well as empirical analysis of monetary policy. The equations for aggregate supply and at times aggregate demand are generally expressed in the form of output gaps as the dependent variable in economic models.

As discussed in Chapter 2, trade-off between inflation and the output gap is crucial to the explanation of business cycle following demand shocks. However, the relationship between the output gap and inflation can also be an important empirical tool to identify nature of the economy, whether it is dominated by supply side factors or demand side factors, an aspect, which is less exploited in the literature. The information content of the output gap can play a useful role in developing an inflation model. This aspect is particularly examined in the present analysis. As pointed out in Chapters 1 and 2, in the case of India, supply side factors are considered as important in the inflationary process as demand side factors. How important are the supply side effects to the inflationary process in an economy is crucial to both modeling inflation as well as conducting monetary policy. This also requires supply side effects to be deciphered. Therefore, emphasis is given to identification of supply as well as the demand side factors, which are crucial to the inflationary process. The rest of the chapter is organized as follows:

A simple analytical role of the output gap is developed in the following section 5.2 in order to identify origin and process of inflation, and whether it is dominated by supply side or demand side factors. In particular, it is shown that in the standard system of downward sloping aggregate demand and upward sloping aggregate supply schedules, if contemporaneous output gap and inflation are negatively related the economy can be considered to be dominated by supply side effects. Section 5.3 estimates an aggregate demand schedule in the inflation output plane and discusses the structure of the demand side of the economy. Section 5.4 estimates output gaps in four different ways. The supply-side structure of the economy is examined by estimating a basic Phillips curve in the inflation output gap plane in section 5.5 using the lagged output gap. The effects of contemporaneous supply and demand side effects are examined by adding a contemporaneous output gap to the basic Phillips curve in section 5.6. Section 5.7 develops a hybrid inflation model for India by using the disequilibrium in mark-up price, discretionary money growth and other supply side variables identified by exploiting the information content of the output gap. In this section, the output gap is further analyzed to firm up the exposition of the Indian economy, particularly the supply side effect. Section 5.8 concludes. A summary of the data used for analysis is presented in Annexure 5.1 of this chapter with additional details provided in Appendix AA of the thesis.

5.2 THE ROLE OF OUTPUT GAP

The simple meaning of the output gap is the difference between actual and potential output. Actual output Y may refer to either output demanded or output supplied, and therefore the output gap can also be referred to as the demand gap or the supply gap. When the output gap is expressed as a fraction of the potential output, then for any time period t, it can be written as follows:

$$GAPY_t = (Y_t - Y_t^P) / Y_t^P \tag{5.1}$$

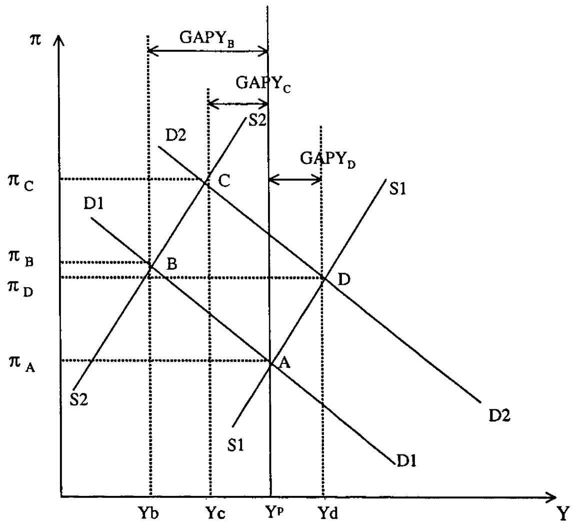
Here, Y is the actual output and Y^P the potential output. Alternatively, this expression can also be written as follows, where y and y^P are the log of actual and potential outputs respectively.

$$GAPY_t \approx (y_t - y_t^P) \tag{5.2}$$

As noted in Chapter 2, with the above definition of the output gap, a widening of the output gap with negative sign means a fall in the output gap, while a widening of the output gap with positive sign means an increase in the output gap. Thus, for a given potential output, algebraically, an increase in actual output will increase the output gap while a decrease in actual output will reduce the output gap. This is illustrated in Figure 5.1, a specific aggregate demand – aggregate supply diagram drawn in inflation (π) output (Y) plane with aggregate schedule sloping downward and aggregate supply schedule sloping upward. Lines DD and SS represent aggregate demand and aggregate supply schedules, respectively. The point of intersection of these two schedules gives the period output and inflation levels. Point A is some reference point corresponding to time t=1, where the output gap as defined earlier is zero. Point B is obtained after a negative supply shock shifting S1S1 to S2S2. Point D is obtained after a positive demand shock shifting D1D1 to D2D2, and point C is obtained after a combination of demand and supply shock. The corresponding inflation levels and the output gaps are labeled on the diagram.

Following the algebraic relationships of equation 5.1 or 5.2, and assuming that potential output is unity, $GAPY_B < GAPY_C < GAPY_D$. At point A, $GAPY_A$ is zero. It may be noted that the width of $GAPY_B$ is more than the width of $GAPY_D$ but their algebraic signs are opposite. Therefore, for a given potential output, an increase in actual output will increase the output gap, while a decrease in actual output will reduce the output gap in the algebraic sense.

Figure 5.1: Movements of the output gap with demand and supply shocks for a given potential output



Now looking at Figure 5.1 and point A as a reference point, it is clear that any point of intersection of SS and DD will lie above and to the left of A (second anticlockwise quadrant with A as origin) and below and to the right of A (fourth anticlockwise quadrant with A as origin) if movement in SS dominates movement in DD. In other words association between algebraic changes in π and GAPY will be negative if SS moves more than DD which means supply side shocks dominate. When demand side shocks dominate, this relationship will be opposite and the points of intersection would lie in the first and third quadrants. Therefore the following proposition holds at least for Figure 5.1:

$$\frac{d(\pi_t)}{d(GAPY_t)} < 0 \text{ if supply shock dominates and} \tag{5.3}$$

$$\frac{d(\pi_t)}{d(GAPY_t)} > 0 \text{ if demand shock dominates} \tag{5.4}$$

In a static setup the above proposition can be algebraically demonstrated as follows. Let potential output be unity so that $\Delta GAPY = \Delta Y$ and supply and demand be represented by the following two equations, where coefficients b_s and b_d are positive scalar quantities, which are assumed to be fixed and ensure dynamic stability. The usual intercept and shift parameters are represented with vectors a_s and a_d. Different values of the shift factors give rise to different equilibrium points.

$$\text{Demand: } Y_d = a_d - b_d \pi \tag{5.5}$$

$$\text{Supply: } Y_s = a_s + b_s \pi \tag{5.6}$$

Taking the differential of the variable terms and representing the differential with a Δ before the term, the two equations can be written as equations (5.7) and (5.8).

$$\Delta Y_d = \Delta a_d - b_d \Delta \pi \tag{5.7}$$

$$\Delta Y_s = \Delta a_s + b_s \Delta \pi \tag{5.8}$$

For equilibrium $\Delta Y_d = \Delta Y_s = \Delta Y$, equations (5.7) and (5.8) solve to yield

$$\frac{\Delta \pi}{\Delta Y} = \frac{\Delta a_d - \Delta a_s}{b_d \Delta a_s + b_s \Delta a_d} \tag{5.9}$$

For the supply side effects to dominate the demand side effects:

$$\frac{\Delta \pi}{\Delta Y} < 0 \quad \text{which means} \quad \frac{\Delta a_d - \Delta a_s}{b_d \Delta a_s + b_s \Delta a_d} < 0 \tag{5.10}$$

Proving its converse proves the above proposition. The converse is: if condition (5.10) holds then the supply side must be the dominant effect. The same is attempted below taking two possible cases.

Case (1): Δa_s and Δa_d are both either positive or negative. Then the sign of (5.9) will be determined by nominator alone, which means

Δa_d - $\Delta a_s < 0 \Rightarrow \Delta a_s$ dominated Δa_d in both cases.

Case (2): Δa_s and Δa_d have opposite sign. Then the sign of (5.10) will be determined by denominator, which means

$(b_s / b_d) \Delta a_d$ - $\Delta a_s < 0 \Rightarrow \Delta a_s$ dominated Δa_d in both cases sufficiently.

Thus, a negative relationship between inflation and the output gap in a system with positively sloping supply schedule and negatively sloping demand schedule means dominant supply side effects in the economy.

This also means that even if potential output moves over time in a dynamic setup, the economy can be considered to be affected more by supply shocks if data show that there is a significant negative relationship between contemporaneous inflation and the output gap.

However, the above result is based on specific characteristics of the aggregate demand and supply schedules, in which demand is downward sloping while supply is upward sloping in the output-inflation plane and dynamic stability is presumed. There could be various characteristics of demand and supply schedules with respect to direction and relative amount of slopes, when the above proposition does not hold. By knowing the nature of demand and supply schedules, particularly if the assumptions about the direction of their slopes holds in the case of India, the relationship between the contemporaneous output gap (or change in the output gap) and inflation can be used to find whether the economy is supply-side or demand-side dominated in the short-run. It is important because not all of the shocks are identifiable. It is likely that the economy will be simultaneously hit by both demand-side and supply-side shocks during the year. In that case, the relationship will depend on the relative strength of the two shocks

As pointed out earlier, in the case of India, supply side factors are well recognized. However, it needs to be verified under the purview of the above proposition. This requires estimating the following: (a) a basic aggregate demand schedule, (b) the output gap in alternative ways (c) a basic short-run supply schedule, and finally (d) the inflation model applying information of the previous three steps. As mentioned earlier, in order to identify demand and supply schedules, the basic supply schedule will be a simple estimation using lagged output gap, while the equation for aggregate demand will be identified by incorporating several variables. The basic idea of supply is that suppliers use previous year's information about the output gap to form prices in the current year. However, the contemporaneous output gap is an outcome of current state of supply and demand shocks.

5.3 INFLATION AND AGGREGATE DEMAND

The complexity of modeling the inflationary process attempted in the subsequent section requires the understanding of basic supply and demand behaviour in India. A plausible relationship between inflation and aggregate demand has been developed in the following section 5.3.1, where two arguments are considered. One is specific to the nature of the Indian economy while the other draws from an assumption that central banks have a mandate to follow a de facto real interest rate rule. The basic idea of the second argument is drawn from Romer (2000). In Section 5.3.2 an equation for aggregate demand is estimated for the Indian data in order to analyze the structure of the demand side of the economy.

5.3.1 Conceptual Framework

The aggregate demand (AD) curve represents the general equilibrium of the money market (represented by the LM curve) and the goods market (represented by the IS curve). The properties and effects of the slope and shift parameters of these two curves were discussed in Chapter 2 on the theory of inflation. In the standard Keynesian model, the intersection of the IS and LM curves represents the equilibrium interest rate and the output with the assumption that inflation is zero, such that the real and nominal interest rate are equal. The other important assumption is that the central bank targets the money supply. Thus, the IS-LM model is not useful for analyzing the effects of inflation unless an aggregate supply (AS) curve is added to make it an IS-LM-AS system or AD-AS system. The AD schedule is downward sloping derived from IS-LM in the output-price plane for a given money stock. In the standard form, the AS schedule is upward sloping in the output-price plane where the assumption is the higher price leads to higher output, a notion already discussed in Chapter 2.

Thus, in the standard literature, the AD and AS curves are considered in the output-price plane. These are not in inflation-output planes, which is more interesting. The important difference here is that inflation may still fall while prices continue to rise. The expected inflation π^e is assumed to be determined outside the model in a standard IS-LM-AS system. This would lead to an upward sloping AD curve in an output-expected inflation plane. This happens because of the vital assumptions that consumption and investment are both inversely related to the real interest rate, and the real interest rate falls with an increase in expected inflation.

However, this assumption may not produce as clear a picture as desired because of their interrelationship through savings.

The above assumption means that general consumption, particularly the consumption of consumer durables, will increase in anticipation of future inflation. This will be more so if the society is near an autonomous consumption level. This increase in consumption will cause a drop in savings and funds available for future investment. Considering that investment is directly dependent on savings, the fund rate is bound to bid up which would then reduce investment demand and growth in general as seen empirically to happen in the Indian case in Chapter 4. In a situation of scarcity of capital, the investment effect may dominate the consumption effect and the AD curve would then be downward sloping in the inflation output plane. This leaves the important observation that the nominal interest rate is in fact dependent on expected inflation. In the case of the United States (USA), Taylor (1993b) found that the Federal Reserve's setting of the funds rate over the past 15 years is well described by a simple function of inflation and output alone. Therefore, the major policy concern of central bankers is to set the interest rate near such that goal variables hit their targets. The money supply should be a secondary concern.

In a recent article, Romer (2000) has highlighted the inconsistency associated with the concept of conventional IS-LM-AS analysis and the practices of the central banks. As previously pointed out, in the common textbook approach of deriving AD curve, the assumption is that the central bank targets money supply. Thus, for a given stock of money, the LM curves shifts down to the right along the IS curve with a fall in the price level as it increases the real stock of money. Thus, for a given expected inflation, both nominal and real interest rates fall, giving rise to different levels of equilibrium aggregate demands and hence different equilibrium output levels. In the process, what happens to the real interest rate if expectations about inflation were not fixed is not clear. In Romer's opinion, this assumption is far away from the point of view of practices of modern central banking. Even countries which resort to monetary targeting tailor monetary targets with an eye on movements in the short-term nominal interest rate and inflationary expectations[55]. In developing countries,

[55] For example, see Clarida, et al. (1998); Bernanke and Mihov (1997); Bernanke and Mihov (1995). These studies indicate that in the case of Bundesbank, the adjustments to interest rate in response to the variations in output, inflation and exchange rate are more prominent than the adjustment in money supply, which is the declared target of monetary policy.

administering the interest rate is often justified due to the presence of an imperfect capital market.

As pointed out in Chapter 1, the main objective of central banking is to achieve maximum sustainable growth at low and stable inflation. Romer (2000) argues that realization of these objectives can be better explained with an assumption that central banks follow a real interest rate rule rather than target the money supply. It took some time for the Indian central bank to be able to realize this but with the financial sector reform commencing in the early 1990s it has been attempting to establish a clear-cut interest rate as the main instrument of monetary policy. However, the real interest rate has always been important for the expansion of credit needs commensurate with growth targets, while at the same time doing every thing possible to contain inflation.

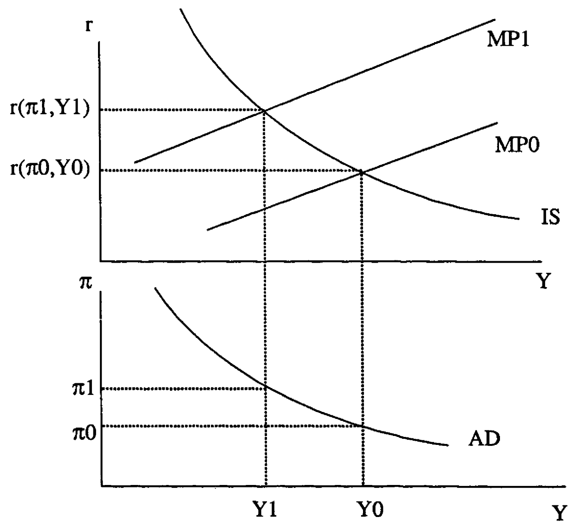
Given the fact that the interest rate is more important to central bankers than the money supply, Romer (2000) has proposed that the LM curve of the IS-LM framework may be replaced by the Monetary Policy (MP) curve, which is a relationship between the interest rate and inflation in its simplest form. However, central banks may also prefer to include other variables in the monetary policy function, particularly output, in order to reduce the fluctuations in these variables. In the short run, central bank changes the nominal interest rate but in the medium-term, they must reconcile with the real rate. Therefore, Romer calls it the real interest rate rule, which is a flat curve for a given level of inflation when only inflation is included in the monetary policy function. When the monetary policy schedule includes both inflation and output, the MP curve would be upward sloping. The important assumption here is that, with an objective of dampening output fluctuations, central banks are likely to cut the real interest rate when output falls and raise it when output rises.[56] This assumption means $r = r(Y, \pi)$, with the function increasing in both arguments and giving rise to an upward sloping monetary policy curve. Further, as it is believed that high output tends to increase inflation while low output decreases it, such a policy would also dampen inflation fluctuations.

The IS curve remains a conventional IS curve sloping downward in the real interest rate output plane. By assumption, an increase in inflation causes the central bank to raise the real rate. Thus, the MP curve shifts up. The shift of the MP curve

[56] With long lags output may be an indicator of inflationary expectations.

causes the economy to move up along the IS curve, causing output to fall. Applying the condition of output equals aggregate demand the inverse relationship between inflation and aggregate demand (AD) is thus established as shown in Figure 5.2.

Figure 5.2 Derivation of aggregate demand schedule in inflation-output plane



Notes: In the above diagram r is the real interest rate, π is the annual percentage inflation, Y is the output, MP is the monetary policy schedule, AD is the aggregate demand schedule. Diagram is based on Romer (2000)

All the factors that can shift the conventional IS-curve are still applicable. However, the role of a change in the stock of money is complicated. In the conventional IS-LM set-up an increase in money stock would shift the AD-curve proportionately to the right. Now, an increase in the money stock at a given level of inflation would lower the real interest rate due to lowering of the nominal rate. With a lower nominal rate the AD curve would shift to the right for all levels of inflation, provided prices have some inertia and do not adjust instantaneously, which is a realistic assumption. Thus, it is seen from the above discussion that downward sloping aggregate demand curve in the inflation output plane can be justified in both the conventional and new set-up of Keynesian analysis. For the Indian data, such a possible aggregate demand curve is estimated in simple form in the following section.

5.3.2 Estimation and Discussion

Aggregate demand for output in its simplest reduced form can be expressed as a function of the real interest rate, world output, and the real exchange rate. Output demand is expected to fall with an increase in the real interest rate (due to a fall in investment) and a currency appreciation (due to a fall in competitiveness). With an increase in world output, aggregate demand is expected to increase. However, in order to capture the full individual effect of inflation, the interest rate is used in its nominal values as a shift parameter for the aggregate demand. The key question is what should be the effect of inflation in such a model? Current inflation can proxy expected future inflation for the annual data series. In a fully developed financial market, money could be replaced with the interest rate, but in India the interest rate was largely administered until 1997. Therefore, it is appropriate to keep both money and the interest rate in the aggregate demand function.

Following the convention of the earlier chapters, the log values are represented by lower case letters and a Δ before a variable represents first differences. The interest rate for this chapter is the lending rate taken in fractions and represented by LRSBI, which is the average lending rate of the state bank of India (SBI). The real exchange rate REER is the effective rate based on trade weighted five-country index as discussed in Appendix AA of this thesis; defined such that a rise in the index means appreciation of the currency. A composite index of industrial production for the five industrialized countries IPIG5 proxy world output as explained in Appendix AA of this thesis and summarized in Annexure 5.1 of this chapter. Following the convention of the earlier chapters, the monetary aggregates and output are taken in logs. As earlier, inflation is expressed in decimals obtained by taking the first difference of logged values of wholesale price index and it is stationary. Among the three monetary aggregates broad money and narrow money are chosen to be included in the aggregate demand function alternatively after a preliminary trials, which indicated base money had no explanatory power. These two monetary aggregates give rise to two different sets of alternative models to be discussed later.

Output, nominal lending rate, world output, real exchange rate, and nominal broad and narrow money are all I(1) with or without trend. Broad money is I(1) without trend and stationary with trend. Both output and money are trended variables. Inflation, expressed as the first difference of log of the wholesale price index, is a stationary variable (see Annexure 5.2 for unit root test results). A test of cointegration between the I(1) variables with trend and VAR of order one, as explained in Annexure 5.3, indicates they are not cointegrated according to the chosen criterion of maximum eigenvalue or trace test in maximum likelihood estimation at 5 percent level. However, when inflation is included in the list of selected variables, cointegration is confirmed (see Annexure 5.4 for the test results). Because inflation is a stationary variable, this may be the reason for obtaining a cointegrating vector, but this test indicates that the OLS estimation of distributed lag model would be consistent and free from possibilities of spurious regression.

Therefore, it is preferred here to model aggregate demand using distributed lag specification and the procedure of general to specific modeling with due care for serial correlation in the resulting error terms. The regression residuals are also tested for a unit root and the test results are presented. The model is identified as aggregate demand because it includes theoretically acceptable demand side variables. Such a distributed lag model estimated with a general to specific approach, which allows for significant variables to appear in the final model with different lags, will also be appropriate for examining the relationship of aggregate demand and inflation.

Since key variables are highly trended, the model is specified around a trend by including a deterministic trend. In case trend is found to be insignificant, it would mean all variables are co-trending, and the trend term will be removed from the model in line with the method of general to specific modeling. Alternatively, if the trend term is significant, the results can be interpreted as the effects of variables on aggregate demand around its trend growth path. However, in order to see the effect of ignoring trend, both a model without considering trend and a model with trend are estimated. Thus, four alternative models are discussed, two with broad money, with and without trend, and two with narrow money with and without trend.

The result of the estimation is presented in Table 5.1. Model AD1 has narrow money and trend, AD2 has narrow money but no trend, AD3 has broad money and trend and AD4 has broad money but no trend. All other variables are almost common. In order to simplify the discussion in this section, a set of general observations with respect to all four specifications is presented first and then the specific property of one of the models, namely AD1, is discussed and compared with other specifications in order to bring about the structural property of the Indian economy with respect to the selected variables.

It may be noted that the trend is significant in all formulations with the selected set of variables. With the trend in the models, lagged output is insignificant, while it becomes significant once the trend is excluded but the R-square of the regression falls. This shows that the model with trend contains more information. The statistical properties of all four models are satisfactory in almost all respects. There is no sign of serial correlation or unit root in the residuals[57]. The predictive failure test and the test for stability of coefficients are also satisfactory. The CUSUM of recursive errors and the CUSUM of square of recursive errors tests also show that there is no structural break (however, test results for model AD1 only are presented in Figures 5.3 and 5.4). Finally, the in-sample predictive errors of the models are very small with high adjusted-R-square around 0.999. However, the models with trend have better fit. The signs of most of the key variables are also as expected. Therefore, it can be concluded that the models are satisfactorily estimated.

The long-run functional relationship between the coefficients of inflation and output is estimated using the variance-covariance matrix and the result is presented in Table 5.1. The long-term inflation elasticity of aggregate demand at the 10 percent level of inflation ranges between -0.023 and –0.029, which is significant at almost the one percent level in all cases. This shows a robust downward sloping aggregate demand curve in output-inflation plane with steep slope.

World output does appear to positively affect demand for domestic goods. An increase in world output has a positive effect on aggregate demand in India, which seems to get a positive boost with real depreciation. It may be recalled that the real exchange rate in this thesis is defined such that a rise in the index means appreciation of the currency. Thus, high domestic inflation implies an appreciation of the currency, which further lowers aggregate demand.

The advantage of including the nominal instead of the real interest rate is clear. The negative relationship between the interest rate and aggregate demand is demonstrated unambiguously, while at the same time the overall independent effect of inflation is estimated. Both variables are significant and therefore the conclusion

[57] Due to small sample size the multivariate version of test statistics are not available. However, considering the single variable test of residual the results are satisfactory.

should remain the same even if the real interest rate were considered separately. Further, it may be noted that the nominal interest rate is more relevant in situations of liquidity constraints and understanding the effects of taxation.

Table 5.1 Estimated equations of aggregate demand (distributed lag structure) (1972-98)

Dependent Variable	y	y	y	y
	AD1	AD2	AD3	AD4
Regressor				
INPT	10.42(1.83)*	6.841(1.21)*	17.28(3.137)*	8.046(1.595)*
y (-1)	0.123(0.123)	0.254(0.12)**	0.0354(0.791)	0.251(0.135)*
Δp	-0.421(0.065)*	-0.447(0.064)*	-0.392(0.063)*	-0.449(0.075)*
Δp (-1)	0.216(0.065)*	0.228(0.071)*	0.180(0.07) **	0.245(0.076)*
LRSBI	-0.838(0.22)*	-0.380(0.134)*	-1.15(0.19) *	-0.99(0.22)***
$reer$ (-1)	-0.397(0.032)		-0.10(0.029) *	-0.067(0.03)***
$ipig5$	0.361(0.120)*	0.503(0.114)*	0.372(0.117) *	0.230(0.133)***
$m1$ (-1)	0.107(0.05)***	0.204(0.038)*		
$m3$			-0.39(0.17) **	
$m3$ (-1)				0.194(0.041)*
T	0.021(0.009)**		0.10(0.003) *	
R-Square	0.99924	0.99898	0.99928	0.9989
R-Bar-Square	0.9989	0.99867	0.99896	0.9985
S.E of Regression	0.0132	0.0145	0.0128	0.0155
Diagnostic Tests				
DW(h)-Statistics	0.172{0.864)	-0.508{0.612}	-0.371{0.711}	0.521{0.602}
LM (1) serial correlation	0.02 [0.89]	0.24 [0.63]	0.09 [0.76]	0.13 [0.72]
LM (3) serial correlation	2.16 [0.54]	3.67 [0.30]	4.72 [0.19]	1.39 [0.71]
Heteroscedasticity CHSQ(1)	0.05 [0.82]	0.00 [0.98]	0.28 [0.60]	1.49 [0.22]
ARCH (3) test	1.50 [0.68]	1.49 [0.68]	1.42 [0.70]	2.47 [0.48]
Functional Form CHSQ (1)	0.31 [0.58]	1.81 [0.18]	0.01 [0.93]	0.01 [0.92]
Normality CHSQ (2)	2.96 [0.23]	3.29 [0.19]	0.32 [0.85]	1.39 [0.50]
Predictive failure CHSQ (6)	1.74 [0.94]	2.54 [086]	2.17 [0.90]	1.26 [0.97]
Predictive failure CHSQ(10)	10.2 [0.42]	3.99 [0.95]	13.0 [0.23]	5.32 [0.87]
Stability test CHSQ (9)	10.3 [0.33]	4.03 [0.78]	7.00 [0.64]	4.91 [0.77]
Residual Unit root				
Test statistics (ADF)	-4.70	-5.197	-5.06	-4.57
Functional Relation				
(a3+a4)/(1-a2)	-0.233(0.077)*	-0.293(0.094)*	-0.220(0.067)*	-0.273(0.102)*

Note: Predictive failure test and parameter stability tests are conducted by breaking the sample at 1992 and 1988; unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values. Estimation method: OLS.

Figure 5.3 Plot of Cumulative Sum of Recursive residuals in model AD1

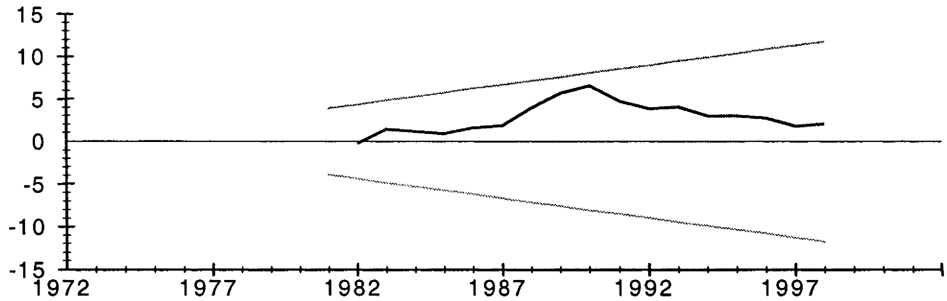
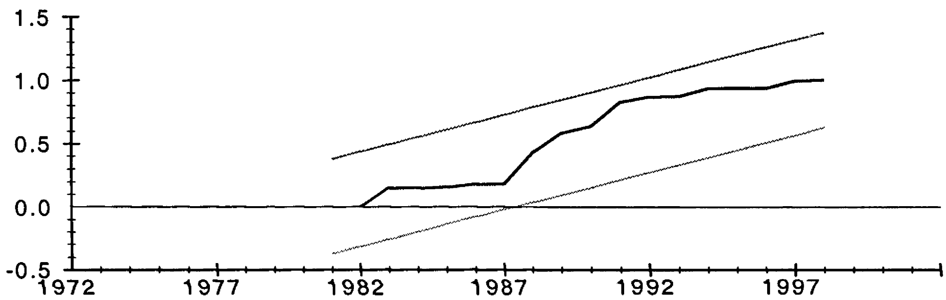


Figure 5.4 Plot of Cumulative Sum of Squares of Recursive residuals in model AD1



All four models are tested for non-nested encompassing and the results indicate the models with trend, namely AD1 and AD3, encompass models AD2 and AD4, respectively, which do not have trends. The AD3 model, which has broad money, encompasses the AD1 model, which has narrow money but AD1 has a better specification in terms of the following conceptual framework. First, an increase in the money supply is expected to shift the aggregate demand function out to the right, which is clearly shown in model AD1 but not in model AD3. Broad money changes sign depending upon whether trend is in the model or not, but narrow money shows consistency in respect of sign, making it a more robust variable than broad money. Second, the coefficient of the trend term in Model AD1 is much smaller at 0.021 when compared to 0.10 in model AD3, which is more desired as economic variables have more to contribute in explaining output. Further, for the sample period it may be noted the average growth of the Indian economy has been around 4.6 percent. Therefore, a 2.1 percent trend growth rate in model AD1 is a better baseline for the present analysis, and further discussion is based on AD1 as the main model.

The trend is a highly significant variable in model AD1 with a positive coefficient of 0.021, which indicates the effects of the other variables can be interpreted around a mean growth level of 2.1 percent. The inflation elasticity of aggregate demand is -0.023 at the 10 percent inflation level. The elasticity increases at lower levels of inflation and falls at higher levels. With steep aggregate demand curve, the economy is sensitive to supply side effects. Any negative (or positive) shock to supply will have large effects on inflation. On the other hand with a flatter supply schedule, the demand side stimulus to the economy synchronized with a positive supply shock may be successful in increasing output without much increase in inflation compared to the stimulus given when there is an adverse supply shock.

Therefore, it may be a better strategy to synchronize the demand side stimulus with positive supply side shocks like good rain, low prices of intermediate goods like imports, and investment on research and development aimed at reducing input costs and increasing general productivity. A trend growth rate of the money supply may lack such synchronization and produce general inflation and reduced growth. It may be noted that government consumption expenditure as a fraction of gross domestic product is not found to be significant in the present specification. Therefore, reducing lending rates and increasing narrow money supply may provide demand side stimulus. According to the preferred model AD1, the long run elasticity of aggregate demand output with respect to narrow money is around 0.10, while at the 10 percent interest rate the interest elasticity of aggregate demand is 0.08, which appears to be reasonable. The average lending rate is about 14.5 percent.

5.4 ESTIMATION OF THE OUTPUT GAPS

The output gap is not observable and its measurement requires estimation of potential output. There are several techniques applied in the literature to measure potential output and these can be broadly classified into two categories.

The first and most common method concerns the use of the time series data of actual output itself and tries to filter out a hypothetical series or fit a trend which is treated as the supply or the potential output. This approach can be called the univariate approach. Fitting a linear trend or fitting a quadratic trend is the simplest of the univariate approaches. Hodrick and Prescott (1997)[58] suggested a detrending procedure to estimate the potential output, which is now widely known as the Hodrick and Prescott (HP) filter. This involves minimization of a quadratic loss function with a chosen weight for smoothing the series. What makes the filtered series a potential one, is freeing it of cyclical fluctuations. Alternative techniques of finding trend are also used in the literature. For example, Coe and McDermott (1997) use the nonparametric regression method. Multivariate versions of the HP filter trend and methods of unobservable components are also used in the literature to estimate potential output (see de Brouwer (1998) for discussion and application of these methods for Australia).

The second method is based on the production function approach, which facilitates measuring the potential output more accurately than the univariate approach. This is because the production function theoretically shows the maximum possible output a country can produce with its given resources and technology. It is generally calculated after removing the cyclical fluctuations from the employment and total factor productivity series using the HP type filter. However, the accuracy of measuring the output gap depends on how precisely the production function itself is estimated.

In the univariate approach to estimation of potential output, it is not clear how the output is technically determined, whereas the production function approach considers the factors of production and the way they are used to get the output through the entire production process. Therefore, the production function approach followed in this study could provide a structurally superior method of estimating potential output. The simple trend, quadratic trend and the HP filter trends are also estimated for comparison with the production function estimates.

5.4.1 Simple Trend Approach

In the simple trend approach, actual output is regressed against a time trend and the fitted value of the regression is taken as the potential output. The equation to be estimated is as follows:

[58] The paper was written in 1980 as working paper of Carnegie Mellon University but was not published until 1997.

$$y_t = a + b\,t \qquad t = 1,2 \ldots \text{n} \tag{5.11}$$

A simple ordinary least square regression of logged real output on time is presented below, which shows a trend growth rate of 4.8 percent for the period 1970-98, with R-square of 98 percent. As explained in the previous chapter, real gross domestic product at 1993-94 market price proxy output. The actual growth during the period has been 4.64, which is close to the estimated value.

$$y^p = \underset{(0.0195)}{14.851} + \underset{(0.0011)}{0.0481}\, t^* \tag{5.12}$$

R-square = 0.98, R-bar-square = 0.99, SE =0.05, ML serial correlation CHSQ (3) =14.25 [0.003], ARCH (3) CHSQ (3) = 8.49 [0.037], functional form RESET CHSQ (1) = 21.92 [0.00], normality CHSQ (2) = 1.02 [0.547], *significant at 1% level. Estimation method: OLS.

5.4.2 Quadratic Trend Approach

In the quadratic trend approach, output is assumed to have quadratic function in time as expressed below. The quadratic term captures the non-linear components of the time series.

$$y_t = a + b\,t + c\,t^2, \qquad t = 1,2 \ldots n; \qquad t^2 = 1,4 \ldots n^2 \tag{5.13}$$

The equation is estimated by the ordinary least squares method considering t and t^2 as two different variables and the result is presented below. Clearly, the quadratic trend equation is better estimated than the simple trend.

$$y^p = \underset{(0.015)}{14.96} + \underset{(0.0024)}{0.0275}\, t^* + \underset{(0.000076)}{0.00069}\, t^{2*} \tag{5.14}$$

R-square = 0.996, R-bar-square = 0.996, SE =0.026, ML serial correlation CHSQ (3) =4.93 [0.177], ARCH (3) CHSQ (3) = 8.68 [0.034], functional form RESET CHSQ (1) = 3.287 [0.07], normality CHSQ (2) = 0.397 [0.82], *significant at 1% level. Estimation method: OLS.

5.4.3 Hodrick - Prescott Filter Approach

The Hodrick-Prescott (HP) filter selects the series of potential output component of the output that minimizes the following loss function, L. It involves fitting the trend path for y^p subject to the constraint that the sum of the squared second differences of the trend series is not too large.

$$L = \sum_{t=1}^{s}(y_t - y_t^p)^2 + \lambda\sum_{t=2}^{s-1}(\Delta^2 y_{t+1}^p)^2 \qquad (5.15)$$

Here, λ is the smoothing parameter on the potential output growth and s is the sample size. The selection of λ is important because the results are sensitive to that. As λ increases and approaches infinity, the loss function is minimized by penalizing the change in the potential growth, which is done by keeping potential output growth constant leading to a linear trend growth rate. On the other hand, as the value of λ approaches zero eliminating the difference between actual and potential outputs minimizes the loss function. The selection of λ also depends upon the frequency of the data. For annual data a value of 7 is suggested in Pesaran and Pesaran (1997:47), that is what is followed in this chapter. The values of y^p that minimize the above loss function are listed in Table 5.4. It can be noted here that the HP filter can generate spurious cyclical patterns as shown by Harvey and Jaeger (1993). However, the advantage of the HP filter is that it renders the output gap stationary over a wide range of smoothing values (Hodrick and Prescott 1997).

5.4.4 Production Function Approach

The production function approach concerns the type of production technology used with core inputs, and how effectively inputs and technology are applied. Thus, the production function approach encompasses the entire production structure and process. Theoretically, a production function shows the maximum possible output that can be produced with the given level of inputs and technology. The maximum possible output is generally called the potential output. Therefore, estimation of the potential output requires the knowledge of the share of capital (K), share of labor (L), value added (Y) and total factor productivity (TFP) of the economy, which can be estimated using the observed values of Y, K, and L.

In the case of India, it is not expected to be able to decipher cyclical changes in unemployment and productivity where unemployment is not documented in the same way as in developed economies. Further, Indian government laws do not permit an easy way of firing labour. Therefore, filtering employment or TFP for the cyclical effects is not expected to make much sense.

With such limitations, a direct approach to estimate the production function itself is considered as an alternative way to fit potential output for India with total productive labor force (LABT) available in the economy as the proxy for labour. A simple Cobb-Douglas (CD) production function with the following specification in value added (Y), capital K and labour L is considered to obtain potential output Y^P.

$$Y_t^P = A[e]^{\alpha t}[K]^{\beta}[L]^{\gamma} \qquad \beta + \gamma = 1 \tag{5.16}$$

In the above equation A is a constant, α is technical progress, and β and γ represent the shares of capital and labour, respectively, in the total output. Actual output need not be equal to potential output due to weather conditions, supply bottlenecks of other inputs, organizational factors and demand conditions. For example, a given labour and capital will produce more output with favourable rain than drought. Thus, the actually observed output can be represented as follows:

$$Y_t = Y_t^P + \varepsilon_t \tag{5.17}$$

Where, ε_t is the deviation of output from potential output and can be named as the output gap. Also, ε_t is assumed to capture other leftover effects of any factor on output, measurement errors in output and deviation from the assumed production structure. Any possible first order auto correlation in ε_t has been corrected applying the method discussed in Pesaran and Pesaran (1997). The first order auto correlation correction can also be interpreted as the correction for the fluctuation in utilization of capital and labour in the production process.

With the estimated series of Y_t^P, the time series for the output gap (GAPY) can be calculated, as ε_t itself represents the difference between actual output and potential output as per the definition stated earlier. However, ε_t represents not only the difference between output and potential output, but also, the impact of other left out variables, deviation from the assumed Cobb-Douglas technology and measurement errors.

Now, concerning the estimation of the potential output, output Y is the real gross domestic product at market price. The measure of capital is the real net fixed capital stock (NFCS), which is obtained by the method of perpetual inventories with five percent depreciation and 1993-94 as the base year as discussed in Appendix AA of this thesis. The instruments include lagged values of NFCS, LABT, deviation of rain from normal (DRAIN), net direct foreign investment as a percentage of gross domestic investment (FDINZI), and real imports (RIM). A summary of data is provided in Annexure 5.1 of this chapter while full details are provided in Appendix AA of the thesis. All variables appearing in non-linear two-stage least squares estimation of output are transformed into indices with 1993-94 as 100. Similarly, time is considered relative to 1993-94, with t=0 for 1993-94. Estimation results of the non-linear two-stage least squares are given in Table 5.2. The period of estimation is 1972 to 1998 (27 observations). The instruments used are: NFCS(-2), DRAIN, LABT(-2), FDINZI(-1), and RIM(-1). The value of 'e' in estimation equation (5.19) is taken as 2.71828.

Table 5.2 Non-Linear Two-Stage Least Squares estimation of potential output (1972-98)

Parameter	Estimate	Standard Error	T-Ratio [Prob]
A	1.018	0.0047	216.6 [0.00]
α	0.0098	0.0038	2.58 [0.02]
β	0.721	0.1206	5.98 [0.00]
$\gamma = (1-\beta)$	0.279		

GR-Squared = 0.996, GR-Bar-Squared[59] = 0.996, R-Squared = 0.995, R-Bar-Squared = 0.994, S.E. of Regression = 2.28, Sargan's CHSQ(1) = 2.29[.130]

Diagnostic Tests

LM(1) test for Serial Correlation CHSQ(1) = 1.257 [0.26]; Sargan's test statistic for serial correlation CHSQ(3) = 4.53 [0.21]; Ramsey's RESET test of Functional Form CHSQ(1)= 0.070 [0.79]; Normality test based on a test of skewness and kurtosis of residuals CHSQ(2) = 0.77 [0.68]; Heteroscedasticity test based on the regression of squared residuals on squared fitted values CHSQ(1)= 0.04 [0.84]

The above coefficients are estimated quite precisely. The shares of labour in the national income during the period of 1993-94 to 1996-97 are presented in Table 5.3 to show that the above estimates compare very well with the actual data. At the same time, the estimation is statistically sound with all the diagnostic results well within limits. Since the actual factor shares and the estimated factor shares of capital and labour are very similar and this indicates that the impact of other left out variables

[59] Generalized R-Squared and Generalized R-Squared Bar are appropriate measures of overall fit when estimation is done by using instrumental variables as discussed in Pesaran and Smith (1994)

and the deviations of the production structure from the assumed Cobb-Douglas framework are not important. Thus ε_t can be expected to represent output gap reasonably well.

Table 5.3 Actual factor incomes during 1993-94 – 1996-97

Year	GDP at current Market Price (Rs million)	CE at current Market Price (Rs million)	OS/MI at current Market Price (Rs million)	NDP at current Market Price (Rs million)	CE as percentage of GDP	CE as percentage of NDP
1993-94	8769520	2529440	4631740	7161180	28.84	35.32
1994-95	10378420	3008200	5455880	8464080	28.99	35.54
1995-96	12179630	3525380	6365910	9891290	28.94	35.64
1996-97	14098490	4053550	7486220	11539770	28.75	35.13

Note: CE = Compensation to employees; OS = Operating surplus; MI = mixed income; NDP = net domestic product; GDP = Gross domestic product.

Source: National Accounts Statistics 1999, Government of India.

5.4.5 Estimated Output Gaps

The complete series of the potential output estimated from the four methods discussed earlier are presented in Table 5.4 along with the actual output and the gaps calculated as a percentage of the potential output. All the output gap values are multiplied with 100 in order to convert them in terms of percentages. Depending upon the method of finding the potential output, the output gaps are named as simple trend gap (GAPYT), quadratic trend gap (GAPYT2), HP filter gap (GAPYH) and production function gap (GAPY).

Potential output in the case of the simple trend, quadratic trend, and HP filter are given in natural logs. Therefore, for calculating the output gaps with these approaches, equation (5.2) has been used where output gap = $((y_t - y_t^p)$. In the case of the production function method, the fitted value is in the form of an index with base 1993-94=100. Therefore, equation (5.1) has been used to calculate the output gap in this case as the fraction of potential outputs where output gap (GAPY) = $(Y_t - Y_t^p)/Y_t^p$. The values of production function gap, GAPY for the period 1970 and 1971 are lost due to the lagged value of the instruments used in the non-linear least square estimation.

Table 5.4 Estimated values of the output gaps (percentage) from the four methods.

Year	Y	YI	y	Simple Trend		Quadratic Trend		HP filter		Prod Function	
				Fitted	GAPYT	Fitted	GAPYT2	Fitted	GAPYH	Fitted	GAPY
1970	3330022	37.97	15.02	14.90	11.96	14.99	3.32	15.01	1.24		
1971	3390504	38.66	15.04	14.95	8.95	15.01	2.16	15.02	1.19		
1972	3369577	38.42	15.03	15.00	3.52	15.05	-1.55	15.05	-1.47	36.26	5.96
1973	3469121	39.56	15.06	15.04	1.62	15.08	-1.87	15.07	-1.12	38.82	1.92
1974	3510482	40.03	15.07	15.09	-2.00	15.11	-4.06	15.10	-3.15	40.48	-1.12
1975	3833096	43.71	15.16	15.14	1.98	15.15	1.23	15.14	1.78	42.69	2.40
1976	3901200	44.49	15.18	15.19	-1.06	15.18	-0.65	15.18	-0.48	43.48	2.32
1977	4181927	47.69	15.25	15.24	1.08	15.22	2.52	15.22	2.50	46.34	2.92
1978	4423231	50.44	15.30	15.28	1.88	15.26	4.21	15.26	4.48	47.95	5.19
1979	4191093	47.79	15.25	15.33	-8.32	15.30	-5.24	15.29	-4.26	49.70	-3.84
1980	4468403	50.95	15.31	15.38	-6.72	15.34	-3.02	15.33	-1.65	54.76	-6.96
1981	4760365	54.28	15.38	15.43	-5.20	15.39	-1.02	15.37	0.36	56.53	-3.99
1982	4940366	56.34	15.41	15.48	-6.30	15.43	-1.77	15.42	-0.64	58.57	-3.81
1983	5307266	60.52	15.48	15.52	-3.94	15.48	0.79	15.47	1.49	61.59	-1.73
1984	5502476	62.75	15.52	15.57	-5.14	15.52	-0.34	15.52	-0.07	63.49	-1.17
1985	5803375	66.18	15.57	15.62	-4.62	15.57	0.11	15.57	-0.09	66.81	-0.95
1986	6085975	69.40	15.62	15.67	-4.67	15.62	-0.15	15.63	-0.90	69.96	-0.80
1987	6376229	72.71	15.67	15.72	-4.82	15.67	-0.64	15.69	-2.03	73.89	-1.59
1988	7008973	79.92	15.76	15.76	-0.17	15.73	3.53	15.75	1.54	78.31	2.05
1989	7469634	85.18	15.83	15.81	1.39	15.78	4.47	15.80	2.30	81.09	5.04
1990	7892483	90.00	15.88	15.86	2.08	15.84	4.41	15.85	2.67	85.13	5.71
1991	7925894	90.38	15.89	15.91	-2.30	15.89	-0.86	15.90	-1.71	90.14	0.27
1992	8355510	95.28	15.94	15.96	-1.83	15.95	-1.42	15.95	-1.43	97.84	-2.62
1993	8769520	100.00	15.99	16.00	-1.80	16.01	-2.56	16.01	-2.06	103.10	-3.00
1994	9463351	107.91	16.06	16.05	1.00	16.07	-1.05	16.07	-0.48	109.29	-1.27
1995	10222850	116.57	16.14	16.10	3.91	16.14	0.42	16.13	0.88	115.45	0.97
1996	10964331	125.03	16.21	16.15	6.11	16.20	1.04	16.20	1.47	122.38	2.17
1997	11510140	131.25	16.26	16.20	6.16	16.27	-0.63	16.26	0.00	130.82	0.33
1998	12210365	139.24	16.32	16.25	7.26	16.33	-1.38	16.32	-0.36	140.82	-1.12

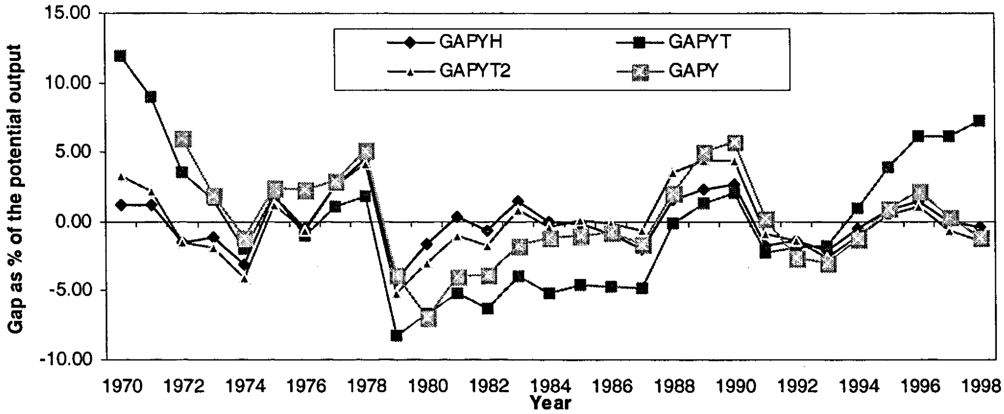
Notes: Y = real GDP at 1993-94 market prices in rupees million; YI = indexed value of Y with 1993-94=100; y = natural log of Y; GAPY = output gap calculated using production function approach of estimating potential output; GAPYT = output gap calculated using simple trend approach of estimating potential output; GAPYT2 = output gap calculated using quadratic trend approach of estimating potential output; GAPYH = output gap calculated using HP filter approach of estimating potential output. All gaps are expressed as percentage of the respective potential outputs i.e. 100 multiply all values of output gaps.

Source: Real output Y from WDI2000 CDROM. Other values are author's estimation and calculation. All values are rounded off up to second digit at the last stage of calculation, therefore, exact values of the output gaps may not be obtained on calculating them taking values of output and potential output from this table.

5.4.6 Time Series Properties of The Output Gaps

The graphical presentation of the above four measures of gap is given in Figure 5.5. The similarity of the patterns of all four measures suggests that all should lead to similar results when applied in the system. However, a method that contains more information to facilitate better modeling of inflation needs to be identified by using the output gap measures in predicting inflation. There are other aspects depending on how the output gaps are calculated. These aspects include the stationarity properties, relative movements over time and information content in explaining inflation. It is expected that the gap should be stationary and mean reverting. If the output gap were not stationary, shocks to the gap would be persistent. To examine this, the unit root test for the gaps calculated by the above four methods is presented in Table 5.5.

Figure 5.5 Output gaps calculated using different measures of the potential output



Notes: The output gaps values are multiplied by 100 to get convert them into percentages.

Table 5.5 ADF based unit root tests for the four estimates of the output gaps.

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend. 95% critical value	Statistic	AIC	SBC
GAPYT	DF	-2.980	-1.55	53.72	52.47
	ADF (1)		-1.42	52.72	50.84
ΔGAPYT	DF	-2.985	-5.70	50.48	49.26
	ADF (1)		-3.83	49.48	47.65
GAPYT2	DF	-2.980	-3.57	59.09	57.83
	ADF (1)		-3.35	58.47	56.58
ΔGAPYT2	DF	-2.985	-6.20	51.75	50.53
	ADF (1)		-4.45	51.11	49.28
GAPYH	DF	-2.980	-4.67	63.82	62.56
	ADF (1)		-4.13	63.45	61.57
ΔGAPYH	DF	-2.985	-7.02	54.50	53.28
	ADF (1)		-5.05	54.35	52.52
GAPY	DF	-2.991	-2.43	51.94	50.76
	ADF (1)		-3.20	52.98	51.22
	ADF (2)		-2.47	52.03	49.68
ΔGAPY	DF	-2.997	-4.02	47.55	46.41
	ADF (1)		-4.03	47.70	46.00

Note: AIC = Akaike Information Criterion and SBC = Schwarz Bayesian Criterion of model selection.

The unit root test has been conducted using the ADF test with order of lag taken as two. Since a trend is not expected in the GAP estimate, the relevant test statistics are the one with intercept. The test for the first difference of the variable is also conducted to confirm they are stationary in the differences. The results presented in Table 5.5 show that the simple trend method does not lead to stationarity while other measures do. GAPY is stationary with one lagged term. All the measures of the gap are stationary in first difference. However, looking at Figure 5.3, it can be seen that the gap measured by simple trend also reverts to mean, but after a longer time interval. This shows limitation of the unit root test in the case of small sample, as is the case here.

5.5 A BASIC SHORT RUN SUPPLY SCHEDULE

Following the discussion in Section 2.3 of Chapter 2, a basic and simple augmented Phillips curve type short-run supply function can be written as follows.

$$\Delta p_t = c_1 + \alpha_1 \, \Delta p_t^e + \beta_1 \, (GAP_i)_{t-1} + \varepsilon_{t1} \tag{5.18}$$

Equation (5.18) represents a basic and simple augmented Phillips curve, which says that current inflation depends on expected inflation and the past output gap. Following the earlier convention, inflation is represented by Δp, where the variables expressed in lower case letter means taken in their log and a Δ before the variable represents first difference of the variable. Variable GAP_i represents the four measures of the output gap: GAPY, GAPYT, GAPYT2 and GAPYH, as discussed earlier. One period lagged inflation $\Delta p\,(-1)$ proxy the expected inflation Δp_t^e. It may be recalled from earlier Chapter 4 that Δp is stationary (see also Annexure 5.2). Taking different measures of the output gaps, equation 5.18 is estimated for the period 1973-98 and the results are presented in Table 5.6.

From the results of the above regression, presented in Table 5.6, it is clear that the lagged value of the output gap is positively related to inflation irrespective of its measure, although it is significant for the production function estimation only. It indicates the existence of a positively sloping short-run supply function. This result is critical as, together with the fact that the aggregate demand schedule estimated earlier is downwards sloping; it invokes the proposition presented in equations 5.3

and 5.4. The positive sign throws light on the price formation behaviour of the suppliers, who base their current prices based on the last period's output gap. However, the explanatory power of the lagged output gap is very poor, except in the case of the production function approach, which has an adjusted R-square value of 10 percent (Table 5.6). With a production function based output gap, the model INFA1 also shows significant inflation stickiness at the 10 percent level, while other models INFA1T, INFA1T2 and INFA1H show insignificant stickiness.

Table 5.6 Basic models of inflation, the augmented Phillips curves (1973-98)

Dependent Variable	Δp	Δp	Δp	Δp
Model number	INFA1	INFA1T	INFA1T2	INFA1H
Regressor				
Constant	0.050 (0.020) **	0.060 (0.02) *	0.056 (0.023) **	0.058 (0.024) **
Δp (-1)	0.374 (0.202) ***	0.287 (0.207)	0.320 (0.249)	0.2927 (0.263)
GAPY (-1)	0.580 (0.33) ***			
GAPYT (-1)		0.190 (0.28)		
GAPYT2 (-1)			0.251 (0.54)	
GAPYH (-1)				0.170 (0.70)
R-Square	0.17	0.08	0.07	0.07
R-Bar-Square	0.10	0.002	-0.009	-0.016
S.E of Regression	0.051	0.054	0.054	0.054
Diagnostic Tests				
LM (1) serial correlation	0.32 [0.57]	0.05 [0.82]	0.66 [0.42]	1.23 [0.27]
LM (3) serial correlation	1.88 [0.60]	2.80 [0.42]	6.26 [0.10]	6.45 [0.09]
ARCH (2) test	4.35 [0.11]	7.79 [0.02]	8.80 [0.01]	8.80 [0.01]
ARCH (3) test	8.78 [0.03]	8.51 [0.04]	8.87 [0.03]	9.22 [0.03]
Functional Form CHSQ (1)	0.15 [0.70]	0.46 [0.50]	0.95 [0.33]	1.22 [0.27]
Normality CHSQ (2)	2.94 [0.23]	0.85 [0.65]	1.31 [0.52]	1.18 [0.56]
Predictive failure CHSQ (6)	1.21 [0.98]	1.79 [0.94]	0.64 [0.99]	0.65 [0.99]
Stability test CHSQ (3)	1.36 [0.71]	2.01 [0.57]	0.73 [0.87]	0.73 [0.87]
Residual Unit root test				
Test statistics (DF)	-4.00	-4.90	-5.21	-5.10

Notes: Predictive failure test and parameter stability tests are conducted by breaking the sample at 1992; unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values. Estimation method: OLS.

5.6 EFFECT OF CONTEMPORANEOUS OUTPUT GAP

With the notations discussed earlier, equation 5.18 can be rewritten to incorporate a contemporaneous output gap as presented in equations 5.19 to 5.20.

$$\Delta p_t = c_2 + \alpha_2 \, \Delta p_t^e + \beta_2 \, (GAP_i)_{t-1} + \gamma_2 \, (GAP_i)_t + \varepsilon_{t2} \qquad (5.19)$$

$$\Delta p_t = c_3 + \alpha_3 \, \Delta p_t^e + \beta_3 \, \Delta \, (GAP_i)_t + \varepsilon_{t3} \qquad (5.20$$

Equation 5.19 is the same as equation 5.18 with contemporaneous gap terms added, while equation 5.20 is obtained by modifying equation 5.19 to see the effect of change in the output gap. Again taking different measures of the output gaps, equations 5.19 and 5.20 are estimated for the period 1973-98 and the results are presented in Tables 5.7 and 5.8, respectively. Adding the contemporaneous output gap term significantly improves the in-sample predictive power of all the models, irrespective of the method of measurement of the output gap and, most importantly, the contemporaneous output gap is significantly negative in all cases as shown in Table 5.7. Therefore, it can be concluded that inflation in India is significantly dominated from supply-side. The improvement in models INF2T (with GAPYT) and INF2 (with GAPY) are also associated with the fact that the lagged output gaps in these models are also significant, while this is not the case in the other two models (with GAPYT2 and GAPYH). Further, the statistical property of models INFA2 and INFA2T are better than for INFA2T2 and INFA2H. However, because of the serial correlation problem in model INFA2H, its R-square value may be spurious.

Replacing the lagged and contemporaneous output gaps by the change in output gap (Table 5.8) improves the statistical as well as the predictive power of all models, while change in output gap term is significantly negative in all cases. However, the improvement in models INFA3T2 and INFA3H is more pronounced than in the other models. With the problem of serial correlation removed, the R-squared values of these models, which is much less that for INFA2T2 and INFA2H, are now more reliable. It may also be noted that in this formulation the output gap as measured by the production function approach remains the best performer.

An overall examination of the results in Tables 5.6 to 5.8 shows that the models containing the output gap as measured by the production function method have better explanatory power and statistical properties than the models containing output gaps calculated by other methods. Owing to this, further discussion and inflation modeling will use the production function approach of the output gap measurement (GAPY).

Table 5.7 Basic models of inflation: effect of contemporaneous output gap (1973-98)

Dependent Variable	Δp	Δp	Δp	Δp
Model number	INFA2	INFA2T	INFA2T2	INFA2H
Regressor				
Constant	0.050 (0.015)*	0.048 (0.017)*	0.053 (0.019)*	0.061 (0.0189)*
Δp (-1)	0.345 (0.155)**	0.426 (0.178)**	0.337(0.201)***	0.251 (0.206)
GAPY (-1)	1.240 (0.30)*			
GAPYT (-1)		1.050 (0.40)*		
GAPYT2 (-1)			0.690 (0.50)	
GAPYH (-1)				0.200 (0.56)
GAPY	-1.276 (0.31)*			
GAPYT		-1.061 (0.3)*		
GAPYT2			-1.364(0.4)*	
GAPYH				-1.710 (0.4)*
R-Square	0.54	0.39	0.42	0.45
R-Bar-Square	0.47	0.30	0.34	0.38
S.E of Regression	0.039	0.045	0.044	0.42
Diagnostic Tests				
LM (1) serial correlation	0.27 [0.60]	0.05 [0.82]	1.93 [0.17]	8.88 [0.003]
LM (3) serial correlation	3.52 [0.32]	4.67 [0.20]	5.04 [0.17]	9.66 [0.02]
ARCH (3) test	3.32 [0.51]	4.49 [0.22]	0.95 [0.87]	1.13 [0.77]
Functional Form CHSQ (1)	4.58 [0.03]	4.65 [0.03]	5.49 [0.02]	5.50 [0.02]
Normality CHSQ (2)	0.32 [0.85]	1.37 [0.50]	0.03 [0.99]	0.02 [0.99]
Predictive failure CHSQ (6)	3.04 [0.80]	1.55 [0.96]	1.74 [0.94]	1.39 [0.97]
Stability test CHSQ (4)	3.40 [0.49]	1.73 [0.79]	1.92 [0.75]	1.55 [0.82]
Residual Unit root test				
Test statistics (DF)	-4.73	-5.34	-4.80	-4.40

Notes: Same as Table 5.6.

Table 5.8 Basic models of Inflation with change in output gap (1973-98)

Dependent Variable	Δp	Δp	Δp	Δp
Model number	INFA3	INFA3T	INFA3T2	INFA3H
Regressor				
Constant	0.050 (0.014)*	0.048 (0.017)*	0.0432 (0.017)**	0.0420 (0.018)**
Δp (-1)	0.352 (0.143)**	0.427 (0.171)**	0.471 (0.177)**	0.491 (0.1865)**
ΔGAPY	-1.260 (0.263)*			
ΔGAPYT		-1.061 (0.30)*		
ΔGAPYT2			-1.11 (0.33)*	
ΔGAPYH				-1.14 (0.37)*
R-Square	0.54	0.39	0.38	0.34
R-Bar-Square	0.50	0.33	0.32	0.28
S.E of Regression	0.038	0.044	0.044	0.046
Diagnostic Tests				
DW-statistics	1.80	1.82	1.84	1.79
LM (1) serial correlation	0.17 [0.68]	0.04 [0.84]	0.02 [0.88]	0.00 [[0.99]
LM (3) serial correlation	3.33 [0.34]	4.67 [0.20]	6.78 [0.08]	7.17 [0.07]
ARCH (3) test	2.81 [0.42]	4.48 [0.21]	4.62 [0.20]	3.23 [0.36]
Functional Form CHSQ (1)	4.49 [0.03]	4.60 [0.03]	2.96 [0.09]	3.03 [0.08]
Normality CHSQ (2)	0.46 [0.80]	1.37 [0.50]	0.11 [0.94]	0.26 [0.88]
Predictive failure CHSQ (6)	3.24 [0.78]	1.64 [0.95]	1.74 [0.94]	1.49 [0.96]
Stability test CHSQ (3)	2.87 [0.41]	1.30 [0.73]	1.48 [0.69]	1.31 [0.73]
Residual Unit root test				
Test statistics (DF)	-4.76	-5.34	-5.72	-5.64

Notes: Same as Table 5.6

5.7 INFLATION MODEL

The above analysis has identified both demand and supply effects on inflation via the output gap. Unfortunately this is not too helpful for policy, because the output gap is difficult to identify fully, particularly when supply side effects dominate. The contemporaneous output gap does not show the possibility of trade-off between inflation and output. It may be recalled that the earlier discussion reveals that both supply and demand shocks can produce an output gap. Therefore, output gap has the power to explain inflation, though in itself the output gap may not be the cause, as would have been the case under the situation of positive relationship between inflation and the output gap. Therefore, an attempt is made in this section to model the inflation process as a reduced form function of supply and demand factors. The catch is to identify at least some of the variables that both cause gap in the short run and at the same time can be considered economically relevant in price formation or demand creation.

A survey of recent research on inflation in India indicates the monetarist way of modeling inflation to dominate the Indian literature, where the price equation is obtained by inverting the demand for money equation.[60] For the reason stated above, a pure monetarist model can at best provide a poor and incomplete specification of the inflation process in India, because long-term price movement may not be simply on account of excess money over nominal income alone as predicted by such models.

Nevertheless, fiscal deficit arising out of increases in government investment without improvement in the tax base must be substantially monetised to ensure that excess government borrowing does not lead to a credit crunch in the private sector, resulting in excess money in the system and inflationary pressure. Therefore, any model of inflation in India cannot ignore money. As seen earlier, the aggregate demand schedule is steep, which means adverse supply shocks and increases in the shift factors of the demand schedule, such as money growth, will together produce more inflation than output. The theoretical discussion in Chapter 2 reveals that

[60] Pradhan and Subramanian (1998), (Arif 1996), Rangarajan (1998:ch 2), are some of the studies where a predominantly monetarist approach has been used. Most recent among these, Pradhan and Subramanian (1997) model the CPI for urban non-manual workers (CPI-UNME) and the CPI for agricultural labour (CPI-AL), which are dominated by food items. However, it may be pointed out that the series on CPI-AL has already been rendered outdated (GOI 1994:58; 1996:77) and the CPI-UME has limited application in conducting monetary policy because of very small basket size, which is directed to address a particular group of the labour force.

money is regarded as the single most important variable in explaining the inflationary process. McCallum (1994) posits that money should not be ignored from any price equation. Further, in view of the possibility of discretion in conducting monetary policy in developing countries like India, money growth becomes a potential variable for explaining inflation.

However, it is also important to identify a potential monetary aggregate that can be treated as exogenous to the inflationary process. Most of the studies in India use broad money to explain inflation, without considering the possibility of it being endogenous to inflation. In the present study an attempt is first made to identify the best monetary aggregate to be introduced in the inflation model using statistical methods such as causality tests.

In recent years, there seems to have been fewer attempts in India to address supply side problems and structure of price formation behaviour on the basis of nominal wages and prices of important inputs and intermediates at the aggregate level. However, Balakrishnan (1991; 1992; 1994)[61] modeled manufactured prices through an error correction model, using annual data for 1952-80, and found that labour and raw material costs are both significant determinants of inflation in the industrial sector. Joshi and Little (1994:257-263) have modeled food and non-food inflation separately by using money, consolidated fiscal deficit, food production and non-food production and import prices as explanatory variables. Callen and Chang (1999) modeled WPI based annual inflation for the period 1957/58-1997/98, with output gaps in industrial and agricultural components of GDP taking them separately as well as combined.[62] They found that the lagged industrial gap was insignificantly positive, while the lagged agricultural output gap was significantly negative and the lagged combined output gap insignificantly negative. This led them to conclude the existence of structural inflation in India. They did not analyze the contemporaneous gaps.

With the above considerations inflation, in India can be modeled in a rather unconventional way by considering three main components of the inflationary

[61] Balakrishnan uses a dataset of same vintage, which is very old and probably cannot be updated due to discontinuation in data compilation. Therefore, the usefulness of such a study is necessarily limited.

[62] Callen and Chang (1999) also model quarterly inflation using index of industrial production based output gap and report signs of output gap term, which is difficult to explain in the standard framework of gap based inflation models.

process: (a) a long-term relationship between wage and general prices in order to capture the adjustment process in a non-homogeneous markup-pricing framework; (b) volatile components of inflation representing short-term expectational impact on general price variation (Δp_E); and (c) inflationary impact of discretionary component of money growth. The scheme can be written as follows:

$$\Delta p = f(Markup\ Adjustment, \Delta p_E, Descretionary\ Money\ Growth) \tag{5.21}$$

Additional variables such as real exchange rate change[63] ($\Delta reer$) and growth in the world output ($\Delta ipig5$), which are important variables in explaining aggregate demand, will also be considered for the final model. The estimation of the final equation of inflation requires estimation of time series for the markup adjustment, a time series for discretionary money growth and identification of variable responsible for expected price variation. The discretionary money growth is obtained as deviation from the long-term growth path of selected monetary aggregate. The markup adjustment is calculated using the concept of cointegration between price and wage. The rest of the discussion is organized as follows: section 5.7.1 discusses the markup adjustment. Expectational components are presented in section 5.7.2. Section 5.7.3 chooses proper monetary aggregate and estimates the discretionary component of money. Section 5.7.4 presents the final model of inflation and demonstrates how the information content of contemporaneous output gap is taken out as direct price forming variables add to the model. Chapter conclusions are provided in section 5.8.

5.7.1 Estimation of Markup Adjustment

Mark-up pricing is the key to several inflation models and has an enduring presence in the literature (de Brouwer and Ericsson 1995). The main idea being that in the long run the domestic price level is a mark-up over total unit costs, including labour costs, import prices, and energy prices. A general form of the price equation based on costs can be written as follows.

---

[63] Exchange rate change is calculated as first difference of log of real exchange rate. Therefore, it is appreciation with positive sign and depreciation with negative sign.

$$P = \mu \prod_{i=1}^{n} X_i^{\alpha_i} \quad , \sum_{i=1}^{n} \alpha_i = 1 \tag{5.22}$$

Here, X_i is the cost of the i^{th} factor, α is the share of the i^{th} factor in total cost and μ is a constant capturing the mark-up. Taking log, the above equation can be represented in the log linear form representing long run relationship in levels. In view of non-availability of clear-cut costs of factors, the homogeneity condition is relaxed, which means the mark-up will include the cost of unaccounted factors. A proxy of labour cost is used as the main cost, determining price in the long run.

The emoluments of public sector employees (WAGP) can be considered as the benchmark salary for workers in other sectors. It is suitable to consider public sector emoluments per capita as the proxy for the cost of price forming agents at the aggregate level. Representing the log of variables by lower case letter, the above equation can be written in log linear form as follows.

$$p_t = a_{0t} + a_1 wagp_t \tag{5.23}$$

Deviation from the equilibrium causes mark up to adjust. The markup adjustment term can be defined as

$$Markup\ Adjustment_t = f(p - a_1 wagp)_{t-1} \tag{5.24}$$

In the empirical literature for time series, the widely accepted method of estimating long run relationships is to apply the principle of cointegration to get the cointegrating vector for the variables under consideration. Following the tradition of the time series analysis, p and $wagp$ are tested for unit roots and the results indicate that both are integrated of order one. Their first differences are stationary (see Annexure 5.2). The long run relationship between the variables is established through the maximum likelihood test of cointegration applying the likelihood ratio test on the maximum eigenvalue and trace of the stochastic matrix in a vector error correction model (VECM) specification (Pesaran, et al. 2000). The structure of the vectors is modeled according to the generalized restriction discussed in Pesaran and Smith (1998). A brief note on the framework of VECM with cointegration is presented in Annexure 5.3 of this chapter and Appendix AB of this thesis. Since both variables are highly trended, the cointegration is carried out with restricted trend and unrestricted intercept in a VAR of order two. The VAR order was selected according to the SBC order selection criterion.

The cointegration test presented in Annexure 5.4 supports the presence of a long run relationship between the two variables. The structural design of cointegrating vector is presented in Annexure 5.5 and the resulting long-term relationship between price and wage is summarized in the following equation 5.28 with standard error given in parenthesis. ERPB is the error term and the short-run dynamics of the price will be a function of this error term. The unrestricted constant of estimation of the short-run equation of price will be combined constant for short as well as long run. It may be recalled from the earlier discussion that the inflation equation is the conjectured short-run price equation.

$$p_t = \underset{(0.0097)}{0.62836}\ wagp_t{}^{*} + \mathrm{ERPB}_t \qquad (5.25)$$

Note: The standard errors are shown in parenthesis ().

The above long run relationship says that for each percentage point increase in total emoluments of public sector employees the WPI increases only by about 0.63 percentage points. The markup has to adjust long run deviations according to ERPB in equation 5.25. There are two main reasons why it can take longer for wage increments to convert into general inflation. First, the employer retains a part of the wages increase as compulsory savings so that they do not immediately reach the hands of labour for consumption. This particularly happens in the public sector. Second, as discussed in Chapter 4, any lump-sum payments received are saved for future bulk expenditures. In both cases, the effects of a wage increase will be delayed.

$$Markup\ Adjustment_t = f(ERB)_{t-1} \qquad (5.26)$$

5.7.2 Expectational Components of Short-Run Price Variation

As discussed earlier, the explanatory power of the contemporaneous output gap with a negative relationship with inflation is derived from the fact that it captures the effects of supply shocks from several sources not appearing in the parsimonious models in Tables 5.7 and 5.8. However, important information regarding the nature of the Indian economy is there, which must be considered when formulating monetary and fiscal policies. Further, the negative sign of the change in the output gap clearly points towards the dominance of supply shifts relative to the demand shifts in the Indian economy. The agricultural sector that forms slightly more than one quarter of GDP is particularly susceptible to weather conditions like rain deviations. Such a supply shock quickly transmits to the manufacturing sector, because a large proportion of agricultural produce is input to the manufacturing sector. This affects general price levels. Some supply shocks are also introduced through the use of new technology and efficiency methods.

Other sources of supply shock can be identified by careful scrutiny of different components of the basket of wholesale price index. After a detailed examination, the annual percentage change in the WPI and its important and volatile components for the sample period 1971-72 to 1998-99 are summarized in Table 5.9, while Table 5.10 presents the correlation matrix of inflation in selected components of the WPI.

The long-run average and overall coefficient of variation (a measure of volatility) of WPI based inflation is very close to that of the manufacturing sector, which supports the stand taken by this study to use the WPI as representative of core inflation in India. The volatility of inflation in manufactured goods and food prices is almost the same, which is the minimum among the subgroups. Control on food price inflation is mostly due to the outcome of strong government interventions.

The primary articles have three main components: food articles with a weight of 17.39, non-food articles with a weight of 10.08 and minerals with a weight of 4.83. Non-food articles are raw cotton, raw jute, oil seeds and other non-food articles, while minerals include petroleum crude, metallic and other minerals. It can be noted that the prices of these primary articles feed into the price of manufacture articles as they form the input and raw material for several articles included in manufacturing. As expected, energy sector inflation has the highest volatility, mainly due to mineral oil price (PMO) inflation.

Within the manufacturing sector, edible oil price (PEO) inflation is the most volatile component. Edible oil is a very sensitive item of general consumption in India. Following earlier convention, mineral oil and edible oil price inflation can be represented with Δpmo and Δpeo, respectively. An important observation can be made from Table 5.10 about the influence of mineral oil and edible oil price inflation on other components of inflation. Although the weight of mineral oil and edible oil in the overall WPI is just 6.7 percent and 2.45 percent, respectively, they are expected to have compounding effects on economy wide prices, as can be seen from their high correlation with other components.

Table 5.9 Pattern of WPI based inflation in India (1971-98)

	Overall WPI	Primary sector		Fuel, power, light and lubricant		Manufacturing sector	
	Total	Total	Food	Total	Mineral oil	Total	Edible Oil
1971-75	10.96	10.14	9.89	15.68	18.88	10.75	6.00
1976-80	7.85	7.21	4.75	9.60	9.54	8.15	10.46
1981-85	6.40	6.70	8.29	9.04	7.46	5.37	5.84
1986-90	7.53	7.68	8.11	6.06	5.72	7.70	12.90
1991-95	9.64	9.93	10.28	5.78	8.32	9.44	6.07
1996-98	5.86	7.35	9.06	16.19	8.91	4.14	4.82
Mean	8.19	8.22	8.35	9.98	9.26	7.84	7.89
Maximum	22.47	24.63	22.75	41.31	52.48	19.07	40.2
Minimum	-1.09	-6.98	-5.64	-17.52	0.00	0.17	-24.2
Standard deviation	5.21	6.74	6.81	10.54	11.35	4.94	13.25
Coefficient of Variation	0.64	0.82	0.63	1.06	1.16	0.63	1.68
Weight in the WPI index (%)	100	32.30	17.39	10.66	6.67	57.04	2.45

Note: All the values of inflation are provided in terms of percentage annual variation. Food is part of primary sector, edible oil is part of manufacturing sector and mineral oil is part of fuel power and lubricant.

Source of basic data: Economic survey (Government of India), various issues. Percentage variations are calculated by author.

Table 5.10 Correlation matrix of sectoral inflation (1971-98)

	Δp	Δpfpl	Δppr	Δpmf	Δpfd	Δpmo	Δpeo
Δp	1						
Δppfpl	0.54	1					
Δppr	0.90	0.42	1				
Δpmf	0.91	0.40	0.66	1			
Δpfd	0.78	0.43	0.91	0.51	1		
Δpmo	0.77	0.85	0.60	0.64	0.55	1	
Δpeo	0.66	0.10	0.86	0.42	0.71	0.28	1

Note: Δp: all commodities WPI inflation; Δpfpl: fuel, power and lubricant price inflation; Δppr: primary product price inflation; Δpmf: manufacturing sector price inflation; Δpfd: Food price inflation; Δpmo: mineral oil price inflation; Δpeo: Edible Oil price inflation.

Interestingly, edible oil inflation, which is part of the manufacturing sector, is not highly correlated with that sector. It can be noted here that edible oil is one of the essential consumption items for Indian households and forms a significant part of food product imports despite the large quantity produced domestically. Thus, the two oil prices together also proxy a sensitive component of import price in India. However, in line with expectations, Δpmo and Δpeo, are not themselves correlated. Therefore, both can be allowed in the inflation model as supply-side variables.

Given the above arguments, it should be the case that the changes in the output gap can be significantly explained with the help of mineral and edible oil price inflation and deviation from normal rain as shown in Table 5.11. Clearly, good rain will shift the supply schedule to the right increasing the output gap, while oil price inflation creates expectation about an increase in general inflation, leading to a shift in the aggregate supply schedule to the left reducing the gap. Money growth is not found to be significant in explaining the variation in the output gap, probably due to the fact that the aggregate demand schedule is steep.

However, growth in foreign exchange reserves ($\Delta feru$) significantly explains change in the output gap. There has been significant growth in India's international reserves during the 1990s, which is not particularly due to export earnings but to non-traditional reasons such as repatriation and deposits by non-resident Indians. The economic survey for 1995-96 (page: 76) reports several measures including increase in cash reserve ratio (CRR), taken during that period to moderate foreign exchange inflows. It is important to recognize the mechanism through which this money can affect the economy. The bank cannot prevent a non-resident individual from sending money to his relatives in India, but fears of excess liquidity cause measures to control overall money growth to be put in place. The result is a shortage of liquidity for business from official sources. The cost of money increases in the informal market and exerts a negative supply shock. Prices rise and the output gap falls. Growth in international reserves can proxy such effects and therefore, the same is used in the regression presented in Table 5.11.

Table 5.11 Determinants of the output gap (1972-98)

$$\Delta GAPY = \underset{(0.007)}{0.013^{***}} + \underset{(0.038)}{0.079}\, DRAIN^{**} - \underset{(0.037)}{0.076}\, \Delta pmo^{***} - \underset{(0.034)}{0.073}\, \Delta peo^{**} - \underset{(0.017)}{0.043}\, \Delta feru^{**}$$

R-square = 0.60, R-bar-square = 0.52. F statistics F (4, 21) = 7.71 [0.00]. SE of regression = 0.02, LM serial correlation CHSQ (1) = 1.02[0.31], LM serial correlation CHSQ (3) = 5.22[0.16]. ARCH (3) CHSQ (3) = 0.56 [0.91]. Functional form RESET CHSQ (1) = 0.26 [0.61]. Normality CHSQ (2) = 1.63 [0.44]. Estimation method: OLS.

*significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

The variables included in Table 5.11 form an important subset of variables, which can be considered potential variables in explaining inflation in India. However, while several variables like money have demand side effect, they are not found to explain gap, but can be important in explaining general inflation because the gap itself does not fully explain inflation.

The short-run price variation is dependent on the factors responsible for the inflationary expectations. As identified above such variables which affect inflation expectations in short term (Δp_E) and generate output gap include mineral and edible oil price inflation and deviation of rain from normal. As discussed in the context of determinants of the output gap, increases in foreign money are also expected to cause supply side inflation. In addition, expectations about current inflation can also be influenced by wage inflation during the period and past general price inflation. Therefore, such variables are presented in equation 5.27 to explain the short run price variation. It may be noted that first three terms of equation 5.27 can also be derived from equation of the form of 5.22 as inflation accounting.

$$\Delta p_E = f(\Delta wagp, \Delta pmo, \Delta peo, DRAIN, \Delta feru, \Delta p(-1)) \qquad (5.27)$$

5.7.3 Choice of Monetary Aggregate and Discretionary Money Growth

Money growth is identified as the key demand side inflationary variable. An examination of the causal relationship between inflation and monetary aggregates can lead to proper choice of macroeconomic specifications for analyzing inflation.[64] As discussed earlier, the three most commonly used monetary aggregates, of the base or reserve money M0, the narrow money M1, and the broad money M3 are used for causality tests. The tests are conducted in a bi-variate setup using two variables, inflation and growth rate of one of the monetary aggregates at a time, because the main motivation of the tests is to understand the relative precedence between inflation and money growth.

[64] Recently, Jadhav, et al. (1992) studied causation between nominal broad money growths and inflation and concluded broad money and inflation had reverse causality. However, they did not study the other monetary aggregates, which is attempted here.

In line with the arguments presented in Chapter 4, two versions of causality tests, the Sims' and the block Granger non-causality test, are also used in this chapter before arriving at conclusions. Chapter 4 is referred for discussion of the methodology. Following the earlier convention, lower case letters represent variables in their log and a Δ before a variable represents the variable in its first difference.

All three monetary aggregates are non-stationary but first difference of their log value $\Delta m0$, $\Delta m1$, $\Delta m3$, respectively, representing monetary growth, are stationary (see Annexure 5.3 for test results) and the same are used for the causality test. Inflation is represented by the first difference of log value of the wholesale price index (Δp). The results are presented in Tables 5.12 and 5.13 according to the two versions of the tests. These results lead to important conclusions. Most importantly, according to both tests, only narrow money M1 demonstrates unambiguous unidirectional causation for inflation. The block Granger non-causality test (Table-5.12) indicates bi-directional causality in the case of the other two monetary aggregates of M0 and M3.

According to the Sims procedure (Table-5.13), the hypothesis that inflation fails to cause base money M0 and broad money M3 is rejected at the 5 percent level, while the hypothesis that M0 or M3 fail to cause inflation is not rejected at the same level. Thus, the Sims test supports unidirectional causation from M1 to inflation and from inflation to M0 and M3. However, the relative P-values in Table 5.12 suggest that causality from inflation to M0 and M3 is stronger than causality from M0 and M3 to inflation.

Table 5.12 'Block Granger non-causality' test of precedence between money growth and inflation in a bi-variate VAR. Direction of non-causality being tested is from x to y (1972-99)

	Monetary Base (M0)		Narrow Money (M1)		Broad Money (M3)	
Test variable (lagged x)	$\Delta m0$	Δp	$\Delta m1$	Δp	$\Delta m3$	Δp
Dependent (y)	Δp	$\Delta m0$	Δp	$\Delta m1$	Δp	$\Delta m3$
CHSQ (1)	6.096 [0.014]	8.131 [0.004]			4.289 [0.038]	15.680 [0.00]
CHSQ (2)			7.724 [0.021]	1.261 [0.532]		
Sign of relationship	(+)	(-)	(+, -)	(-, +)	(+)	(-)

Notes: The order of VAR, selected according to SBC selection criteria is 1 for M0 and M3 while it is 2 for M1. P-values for Chi-Square statistics are given in square brackets []. The statistics is to test the null hypothesis that coefficients of the lagged values of the explanatory variable x in the equation of the y variable are zero. A lower P-value means rejection of the hypothesis and therefore that demonstrates existence of the causal direction from x to y.

Table 5.13 Sims test of forecasting ability between money growth and inflation in a bi-variate OLS regression. Direction of non-causality being tested is from y to x (1972-99)

	Monetary Base (M0)		Narrow Money (M1)		Broad Money (M3)	
Test variable (future x)	Δp	$\Delta m0$	Δp	$\Delta m1$	Δp	$\Delta m3$
Dependent (y)	$\Delta m0$	Δp	$\Delta m1$	Δp	$\Delta m3$	Δp
CHSQ (1)	2.770 [0.096]	5.380 [0.02]	4.397 [0.036]	1.929 [0.165]	1.346 [0.246]	14.033 [0.000]
Sign of relationship	(+)	(-)	(+)	(-)	(+)	(-)

Note: One past and one future value are considered in system for M0 and M3, while two past and one future value is considered for system with M1. P-values for Chi-Square statistics are given in square brackets []. The statistics is to test the null hypothesis in a Wald test that coefficient of the future value of the x variable γ in the equation for the y variable is zero. A higher P-value means that the hypothesis of zero coefficients for future value of x is not rejected and therefore that demonstrates non-rejection of the non-existence of the causal direction from y to x supporting non-existence of causal direction from y to x. Equation estimated for this test is $y_t = c - \sum_{j=1}^{\infty}\alpha_j y_{t-j} + \sum_{j=0}^{\infty}\beta_j x_{t-j} + \sum_{j=1}^{\infty}\gamma_j x_{t+j} + v_t$. For detail of this test, refer to Chapter 4.

Thus, for explaining inflation as a monetary phenomenon, the appropriate monetary aggregate for India is clearly M1. The other two monetary aggregates of M3 and M0 appear to be influenced by considerations of accommodating inflation by the monetary authorities. Therefore, these aggregates are not appropriate for modeling inflation in India.

Having selected narrow money as the preferred monetary aggregate for modeling inflation, the discretionary component of monetary growth is calculated under the assumption that in the long term monetary authorities would have planned the same trend growth rate which best fits the data. Any deviation from that trend growth rate is surprise growth in money due to the discretionary considerations. The trend growth rate of M1 for the sample period, estimated using the Cochrane-Orcutt method of adjustment for first order serial correlation, is obtained as 14.089 percent. Therefore, the discretionary or surprise growth in M1 ($\Delta m1dis$) is obtained using the following relationship:

$$\Delta m1dis = \Delta m1 - 0.14089 \qquad (5.28)$$

5.7.4 Final Model of Inflation

Considering equations 5.21, 5.26, 5.27 and 5.28, the final model for inflation can be written in the following distributed lag framework, which will also be consistent with error correction representation of the relationship between price and wage, in which case other variables than deviations in price and wage can be considered additional short term price determinants.

$$\begin{aligned}\Delta p = a &+ \sum_{i=1}^{n1} a_i ERB_{t-i} + \sum_{i=0}^{n2} b_i \Delta wagp_{t-i} + \sum_{i=0}^{n3} c_i \Delta pmo_{t-i} + \sum_{i=0}^{n4} d_i \Delta peo_{t-i} \\ &+ \sum_{i=0}^{n5} e_i \Delta feru_{t-i} + \sum_{i=0}^{n6} f_i DRAIN_{t-i} + \sum_{i=0}^{n7} g_i \Delta m1dis_{t-i} + \sum_{i=1}^{n8} h_i \Delta reer_{t-i} \\ &+ \sum_{i=0}^{n9} j_i \Delta ipig5_{t-i} + \sum_{i=1}^{n10} k_i \Delta p_{t-i} + \varepsilon_t\end{aligned} \tag{5.29}$$

The estimation is carried out starting with a general lag structure of two for all variables (n1 = n2 = n3 = n4 = n5 = n6 = n7 = n8 = n9 = n10 =2), and the model is then searched downwards. Equation 5.29 does not include contemporaneous real exchange rates, as it contain contemporaneous inflation in its construction. However, contemporaneous nominal exchange rate change ($\Delta neer$) and world inflation ($\Delta cpig5$) were examined for explanatory power (see Annexure 5.1 for definition of these variables). Variables found to be insignificant in contributing to the explanatory power of the model are systematically removed. The estimated final form model is presented in Table 5.14. It may be noted that DRAIN, lagged inflation, lagged real exchange rate change, lagged and contemporaneous nominal exchange rate change, world inflation, and world output growth did not significantly improve the model and therefore do not appear in the final model.

The variables that significantly explain general inflation in India are growths in public sector wages, oil prices, narrow money stocks and foreign exchange reserves as shown in model INFB1. In a related context Woo (1984) has demonstrated that among several foreign trade variables, the price of imported oil alone along with domestic wage in the private non-farm economy leads to an acceptable specification for prices of non-food, non-fuel products in the United States.

Model INFB1 is precisely estimated with satisfactory statistical properties. Its explanatory power with R-square of 93 percent is much higher than the simple models of Tables 5.6 to 5.8. The fitted and actual values of the model are shown in Figure 5.6. The short-run forecasting properties of the model appear to be satisfactory (see Chow's predictive failure and coefficient stability test results in Table 5.14 and one year ahead forecasted value in Figure 5.6). The errors of prediction for the model are well within two standard error bands. The CUSUM and CUSUM of squares plot provided in Figures 5.8 and 5.9, respectively do not indicate any signs of structural break.

Model INFC1 has been tested for stability using Chows F-test by breaking at various points as permitted by the number of variables in the model. It appears that the variable of growth in the international reserve became important only during 1990s, when India's international reserves increased substantially. Other variables are found to be stable for most periods.

There are several other sources of supply and demand side changes, which may not be easy to model specifically. Therefore, output gaps could still have some additional information content. Particularly, the combined effects of DRAIN, exchange rate appreciation foreign output, technological improvements and economic reforms have an impact on the inflationary process. With this consideration, it is logical to include the output gap and test the model for any improvement.

After adding the output gap with model INFB1, the results are presented in model INFB2. Clearly, output gap now contains less information, as the size of its coefficient is significantly lowered to 0.3 from 1.25 in model INFA2 in Table 5.7. The adjusted R-square improves by only 2 percentage points. The fitted values from model INFB2 are shown in Figure 5.10, which indicates improvements in in-sample forecasting inflation particularly during the 1990s. Further, the negative sign associated with the contemporaneous output gap indicates it is an outcome of shocks dominated by supply side *inter alia* improvements in productivity, weather conditions or the positive effects of economic reforms. It may also be noted that variables explaining the output gap in Table 5.11 have opposite signs in model INFB1 and INFB2, which shows consistency in the transmission mechanism of inflationary process.

Table 5.14 A hybrid model of inflation for India with money and markup price (1972-98)

Dependent Variable	Inflation (Δp)	Inflation (Δp)
Model number	INFB1	INFB2
Regressor		
Constant	-0.544 (0.165)*	-0.801 (0.159)*
Markup adjustment ERPB (-1)	-0.229 (0.065)*	-0.332 (0.063)*
Wage inflation $\Delta wagp$	0.167 (0.073)**	0.206 (0.061)*
Mineral oil price inflation Δpmo	0.235 (0.036)*	0.213 (0.030)*
Edible oil price inflation Δpeo	0.137 (0.033)*	0.119 (0.028)*
Edible oil price inflation Δpeo (-1)	0.078 (0.037)**	0.073 (0.030)**
Discretionary money growth $\Delta m1dis$	0.197 (0.055)*	0.168 (0.046)*
Discretionary money growth $\Delta m1dis$ (-1)	0.230 (0.065)*	0.199 (0.054)*
Growth in Foreign Exchange reserves $\Delta feru$	0.027 (0.014)***	0.021 (0.012)***
Contemporaneous output gap GAPY		-0.334 (0.108)*
R-Square	0.932	0.957
R-Bar-Square	0.902	0.934
S.E of Regression	0.0165	0.0136
F statistic, F (k-1, n-k), n=27, k= no. of regressors including intercept	30.89 [0.00]	41.72 [0.00]
Diagnostic Tests		
DW-statistics	1.60	1.78
Serial correlation, LM (1)	1.90 [0.17]	0.56 [0.45]
Serial correlation, LM (2)		3.76 [0.15]
Serial correlation, LM (3)	3.33 [0.15]	8.47 [0.04]
Serial correlation, F (3, 13)	1.23 [0.33]	2.13 [0.14]
Heteroscedasticity CHSQ (1)	0.10 [0.75]	0.81 [0.37]
ARCH (3) test	4.80 [0.19]	0.07 [0.99]
Functional Form CHSQ (1)	0.51 [0.47]	0.13 [0.72]
Normality CHSQ (2)	0.16 [0.92]	1.78 [0.41]
Predictive failure (a) CHSQ (6)	3.94 [0.68]	6.17 [0.41]
Predictive failure (b) CHSQ (1)	2.05 [0.15]	
Stability test CHSQ (9)	13.4 [0.15]	
Stability test CHSQ (10)		15.56 [0.11]
Residual Unit root test		
Test statistics (DF)	-4.05	-4.15

Notes: Predictive failure test (a) is done after breaking the sample at 1992. Predictive failure test (b) is done for future values beyond 1998, the estimation period. The wage growth data for 1999 is assumed to be similar to 1998 for predicting 1999 inflation as the same is not available. The parameter stability tests are conducted after breaking the sample at 1987. The unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values. The error term ERPB is obtained from equation (5.28). Estimation method: OLS.

Figure 5.6 Actual, fitted, and forecasted values of inflation in model INFB1

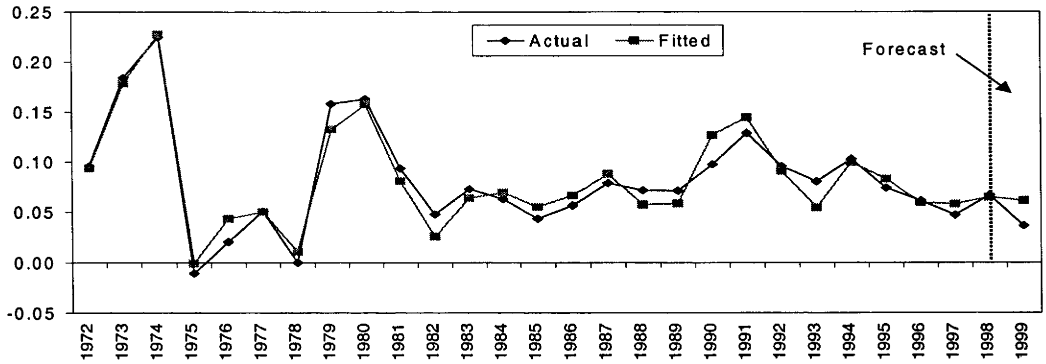


Figure 5.7 Plot of the residuals and two standard error band in model INFB1

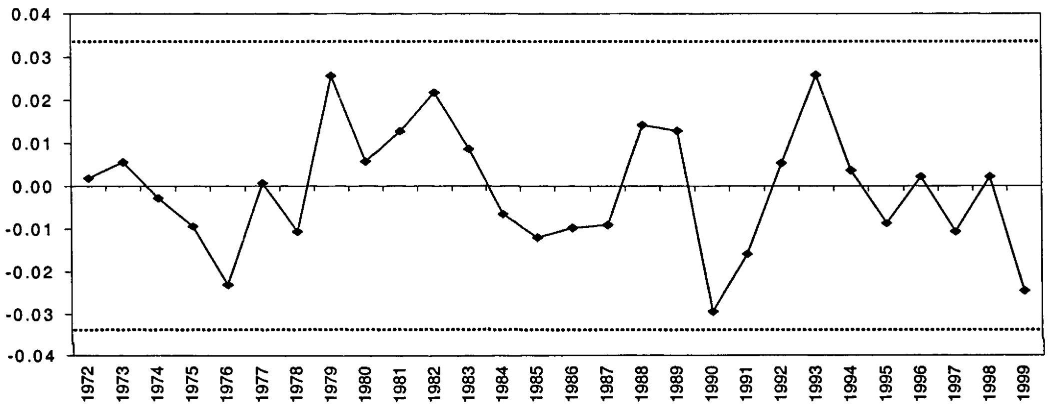
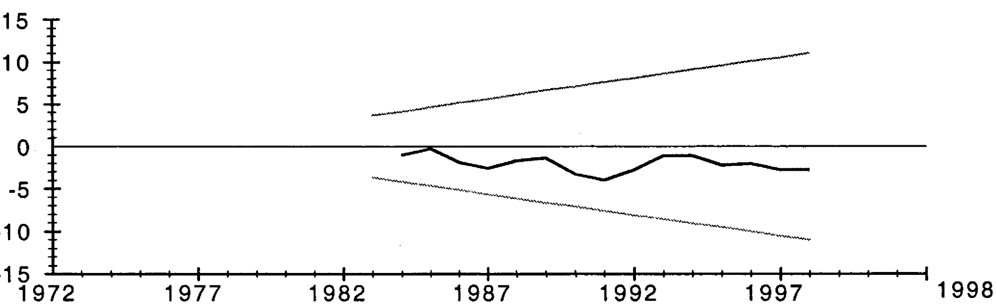


Figure 5.8 Plot of Cumulative Sum of Recursive Residuals in model INFB1



The straight lines represent critical bounds at 5% significance

Figure 5.9 Plot of Cumulative Sum of Squares of Recursive Residuals in model INFB1

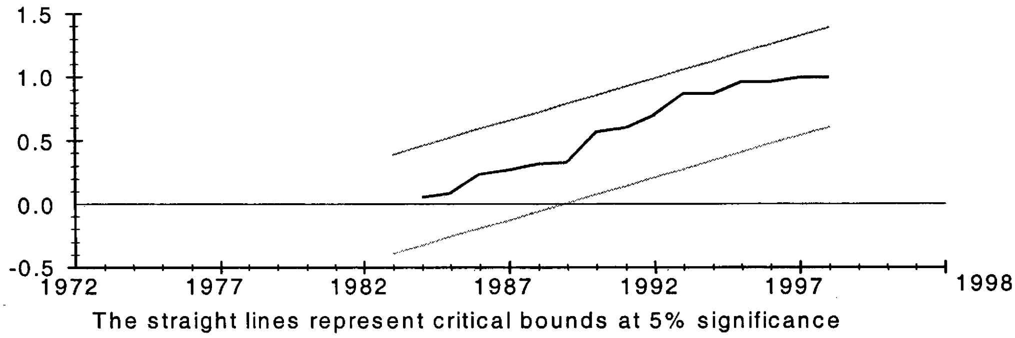


Figure 5.10 Actual, fitted, and forecasted values of inflation in model INFB2

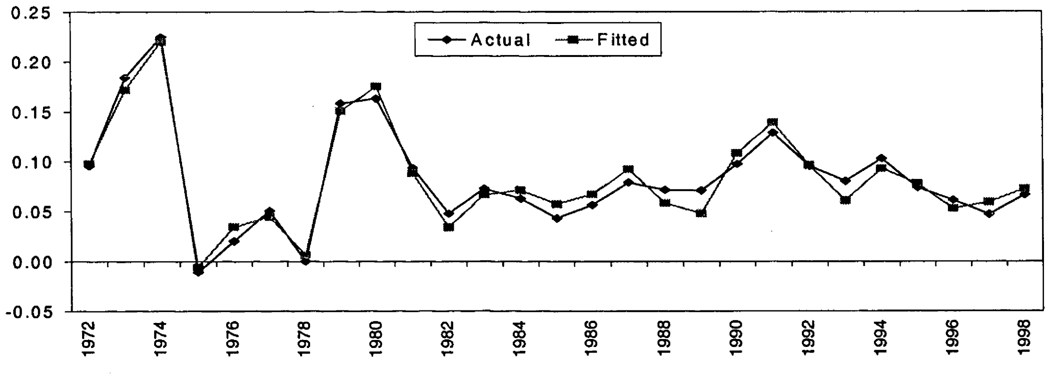
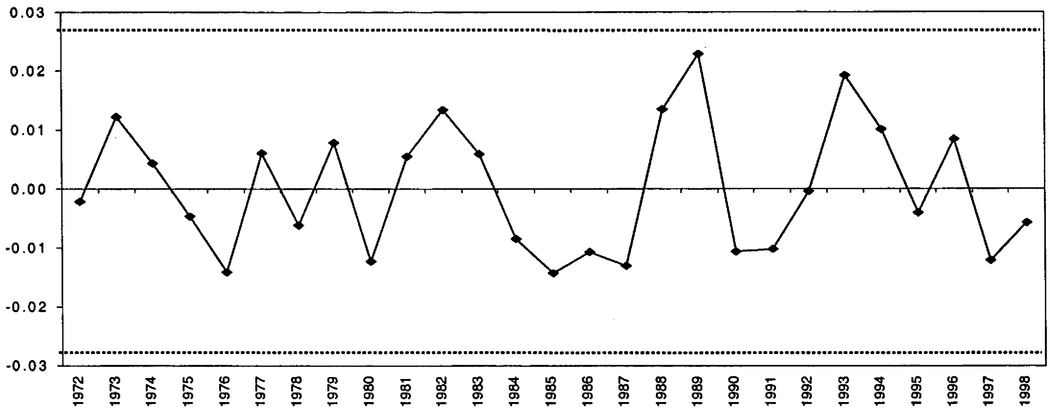


Figure 5.11 Plot of the residuals and two standard error bands in model INFB2



5.8 CONCLUSION

The analysis in this chapter indicates the concept of the output gap can successfully be used in the case of India to identify whether the economy is dominated by supply side factors. The most interesting outcome is the negative association between inflation and the contemporaneous output gap. With a downward sloping aggregate demand schedule and upward sloping supply schedule, a negative relationship between inflation and the output gap indicates the profound impact of the supply side of the economy on inflation. It also shows that the output gap contains important information about the inflationary process in India and both supply and demand side variables are important in understanding the inflationary process.

This chapter reviewed two major approaches for determining the output gaps. One is the univariate approach, which includes three methods of linear time trend, quadratic time trend and the HP filter, and the other is the production function approach. The profiles of the output gaps generated by all four methods are quite similar and produce the same kind of results when used to model simple supply function. However, despite broad similarity in the results, the output gap calculated using the production function approach appears to be superior in reducing ex post prediction error in modeling inflation in the simple way.

Using the information content of the output gap, a mark-up price model of inflation with discretionary narrow money growth, wage inflation, oil prices inflation, and growth in international reserves has been developed and evaluated. It shows that such a model performs well in explaining inflation in India and the performance of the model can be enhanced if more information about the output gap can be foreseen. To the basic question of 'can monetary policy affect inflation in India' the answer is clearly 'yes'. It is important to note that narrow money growth has been systematically introduced in the model based on the causal relationship of this variable with inflation. There is a clear unidirectional causality running from narrow money growth to inflation in India and not vice-versa as was found in the case of base money and broad money. Therefore, narrow money is an important causal variable for explaining inflation. To control inflation, the monetary authority should be concerned with the growth rate of narrow money rather than with other aggregates. On the other hand, narrow money is not an instrument controlled by the central bank; the instrument is base money or the interest rate or cash reserve ratio

(CRR). Therefore, the narrow money multiplier needs to be modeled using these instruments, which is done in Chapter 7.

Annexure 5.1 Summary definition of data used in Chapter 5

Symbol	Variable description and unit of measurement
CPIG5	Trade weighted consumer price index of G5 countries (Germany, France, Japan, UK and USA) calculated from monthly series (line 64) of IFS. Base: 993-94=100)
DRAIN	Ratio of change in rainfall index from the 50-year average index for June-Sep.
FDINZI	Foreign direct investment, net inflows as percentage of GDI
FERU	Foreign exchange reserves including gold (US $, million)
GAPY	Output Gap measured as fraction of the potential output, which is measured by production function method
GAPYT	Output Gap measured as fraction of the potential output, which is measured by simple trend method
GAPYT2	Output Gap measured as fraction of the potential output, which is measured by quadratic trend method
GAPYH	Output Gap measured as fraction of the potential output, which is measured by HP filter method
IPIG5	Trade weighted industrial production index of G5 countries (Germany, France, Japan, UK and USA), calculated from monthly indices (line 66) of IFS. Base: 993-94=100)
LABT	Total labour force (million)
LRSBI	Average annual lending rate of State Bank of India (SBI) expressed in fractions. For the data given in ranges the middle point is taken.
M0	Base (Reserve) Money (rupees million). M0 = Currency with the Public (CUP) + Currency in hands of commercial banks (CIB) + Bankers' Deposits with RBI (BDR) + Other Deposits with RBI (ODR)
M1	Narrow Money (rupees million). M1 = Currency with the Public + Demand Deposits with Banks (DD) + Other Deposits with RBI
M3	Broad Money (rupees million). M3 = M1 + Time Deposits with Banks (TD)
NEER	Nominal trade weighted effective exchange rate of G5 countries defined such that an increase indicate appreciation
NFCS	Estimated net fixed capital stock at 1993-94 prices with 5% depreciation (rupees million).
P	Wholesale price index (WPI) of all commodities converted to base 1993-94 = 100
PEO	WPI for edible oil included in the basket of general WPI at base 1993-94 = 100
PMO	WPI for mineral oil included in the basket of general WPI at base 1993-94 = 100
RIM	Imports of goods and services at constant price (rupees million)
REER	Trade weighted real effective exchange rate of G5 Countries defined such that an increase indicate appreciation
WAGP	Emoluments of public sector employees expressed as rupees per capita
Y	Gross domestic product at constant market prices (rupees millions)

Annexure 5.2 Unit root test for variables used in Chapter 5 in levels and first differences

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend. 95% critical value	Statistic	AIC	SBC	The Dickey-Fuller regressions include an intercept and a linear trend 95% critical value	Statistic	AIC	SBC
GAPY	DF	-2.991	-2.43	51.94	50.76	-3.612	-2.36	50.95	49.18
	ADF (1)		-3.20	52.98	51.22		-3.12	52.00	49.64
	ADF (2)		-2.47	52.03	49.68		-2.41	51.04	48.09
ΔGAPY	DF	-2.997	-4.02	47.55	46.41	--3.622	-3.92	46.57	44.87
	ADF (1)		-4.03	47.70	46.00		-3.96	46.79	44.51
			-3.36	46.92	44.65		-3.32	46.06	43.22
GAPYT	DF	-2.980	-1.55	53.72	52.47	-3.594	-2.13	54.93	53.05
	ADF (1)		-1.42	52.72	50.84		-1.85	54.22	51.71
ΔGAPYT	DF	-2.985	-5.70	50.48	49.26	-3.603	-6.10	50.85	49.02
	ADF (1)		-3.83	49.48	47.65		-4.35	50.18	47.74
GAPYT2	DF	-2.980	-3.57	59.09	57.83	-3.594	-3.50	58.16	56.27
	ADF (1)		-3.35	58.47	56.58		-3.30	57.58	55.06
ΔGAPYT2	DF	-2.985	-6.20	51.75	50.53	-3.603	-6.10	50.85	49.02
	ADF (1)		-4.45	51.11	49.28		-4.35	50.18	47.74
GAPYH	DF	-2.980	-4.67	63.82	62.56	-3.594	-4.57	62.83	60.95
	ADF (1)		-4.13	63.45	61.57		-4.05	62.49	59.97
ΔGAPYH	DF	-2.985	-7.02	54.50	53.28	-3.603	-6.88	53.54	51.71
	ADF (1)		-5.05	54.35	52.52		-4.93	53.37	50.93
*ipig*5	DF	-2.98	-0.33	50.17	48.91	-3.59	-2.86	53.09	51.20
	ADF (1)		-0.37	49.42	47.53		-4.38	56.51	54.00
	ADF (2)		-0.27	50.52	48.00		-3.62	55.80	52.65
Δ*ipig*5	DF	-2.98	-4.67	48.40	47.19	-3.59	-4.63	47.60	45.78
	ADF (1)		-5.07	49.40	47.57		-4.98	48.52	46.08
*m*0	DF	-2.980	-0.17	33.69	32.44	-3.594	-2.95	36.86	34.97
	ADF (1)		-0.15	32.71	30.82		-3.41	37.20	34.68
Δ*m*0	DF	-2.985	-4.93	32.06	30.84	-3.603	-4.83	31.08	29.25
	ADF (1)		-4.17	31.64	29.81		-4.09	30.68	28.24
*m*1	DF	-2.980	1.07	33.00	31.74	-3.594	-2.19	34.70	32.81
	ADF (1)		1.49	33.54	31.65		-1.77	34.56	32.05
Δ*m*1	DF	-2.985	-6.30	31.52	30.30	-3.603	-6.91	32.39	30.56
	ADF (1)		-4.03	30.59	28.76		-4.88	32.14	29.70
*m*3	DF	-2.98	0.23	58.45	57.19	-3.59	-3.20	62.26	60.38
	ADF (1)		0.23	57.51	55.62		-3.70	62.82	60.30
	ADF (2)		0.28	56.96	54.44		-3.77	62.70	59.56
Δ*m*3	DF	-2.99	-5.08	55.66	54.44	-3.60	-4.98	54.71	52.88
	ADF (1)		-4.10	55.09	53.26		-4.02	54.14	51.70
p	DF	-2.980	-1.05	38.18	36.92	-3.594	-3.20	41.70	39.82
	ADF (1)		-0.92	37.90	36.01		-4.93	46.33	43.82
	ADF (2)		-0.93	38.80	36.28		-4.28	45.75	42.61
Δ*p*	DF	-2.985	-4.10	38.41	37.19	-3.6027	-3.97	37.41	35.58
	ADF (1)		-4.43	39.00	37.17		-4.29	38.01	35.57
	ADF (2)		-3.57	38.16	35.73		-3.47	37.18	34.14

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
peo	DF	-2.980	-1.23	15.26	14.00	-3.954	-3.65	19.67	17.78
	ADF (1)		-1.23	14.33	12.44		-4.57	21.48	18.97
	ADF (2)		-1.41	21.42	18.90		-1.90	22.23	19.08
Δpeo	DF	-2.985	-5.89	16.91	15.69	-3.6027	-5.65	15.91	14.08
	ADF (1)		-7.86	22.17	20.34		-7.63	21.37	18.93
	ADF (2)		-3.84	21.21	18.78		-3.76	20.38	17.33
pmo	DF	-2.980	-2.42	20.16	18.90	-3.954	-3.85	24.19	22.30
	ADF (1)		-2.19	19.85	17.96		-4.77	26.62	24.11
	ADF (2)		-2.50	21.32	18.81		-3.90	25.95	22.80
Δpmo	DF	-2.985	-3.55	18.15	16.93	-3.603	-3.64	17.59	15.76
	ADF (1)		-4.07	18.89	17.06		-4.35	18.90	16.46
	ADF (2)		-3.51	18.17	15.74		-4.00	18.78	15.73
reer	DF	-2.98	0.09	29.29	28.03	-3.59	-1.90	30.44	28.56
	ADF (1)		0.00	28.40	26.52		-2.02	29.85	27.34
$\Delta reer$	DF	-2.99	-4.44	28.14	26.92	-3.60	-4.37	27.21	25.39
	ADF (1)		-2.91	27.27	25.44		-2.84	26.31	23.87
LRSBI	DF	-2.98	-2.62	73.36	72.11	-3.59	-1.39	72.98	71.09
	ADF (1)		-2.57	72.38	70.49		-1.09	72.09	69.58
ΔLRSBI	DF	-2.99	-4.62	66.84	65.62	-3.60	-5.88	69.50	67.67
	ADF (1)		-3.45	65.94	64.11		-5.27	70.18	67.74
	ADF (2)		-2.39	64.95	62.51		-4.78	70.70	67.65
wagp	DF	-2.980	-0.46	33.24	32.02	-3.594	-3.50	37.71	35.88
	ADF (1)		-0.13	34.17	32.34		-2.63	36.71	34.27
	ADF (2)		0.85	39.15	36.71		-1.28	39.19	36.15
$\Delta wagp$	DF	-2.985	-6.38	35.53	34.35	-3.603	-6.29	34.79	33.03
	ADF (1)		-6.35	37.87	36.11		-6.45	37.58	35.23
	ADF (2)		-4.48	37.44	35.08		-5.11	38.54	35.60
y	DF	-2.980	1.24	53.29	52.04	-3.594	-2.13	54.93	53.05
	ADF (1)		1.58	52.98	51.09		-1.85	54.22	51.71
Δy	DF	-2.985	-5.70	50.48	49.26	-3.603	-6.10	50.85	49.02
	ADF (1)		-3.83	49.48	47.65		-4.35	50.18	47.74

Note: ADF = Augmented Dickey Fuller. AIC = Akaike Information Criterion. SBC = Schwarz Bayesian Criterion of model selection. The order of ADF test is chosen as two in all the cases. Numbers of observations vary from 23 to 26

Annexure 5.3
A brief note on cointegration and ECM

An (n x 1) vector time series y_t is said to be cointegrated if each of the series taken individually is I(1), that is, nonstationary with a unit root, while some linear combination of the series $a' y_t$ is stationary or I(0) for some nonzero (n x 1) vector a. In a specific representation, distributed lag models can be rearranged to incorporate variables in their levels as well as their differences allowing the analysis of both short-run and long run properties of the variables called the Error Correction Model (ECM).

Drawing on Hamilton (1994: chapters 18, 19), Johansen (1995: Chapter 4), Pesaran & Smith, (1998), Pesaran and Shin (1998), a description of a cointegrated vector error correction model (VECM) with generalized restrictions for empirical analysis is also provided in Appendix AB of the thesis. Briefly, with y_t as a $m x 1$ vector of all jointly determined endogenous variables, which can be represented as the underlying p th-order augmented vector auto regression is as follows:

$$\Phi(L) y_t = a_0 + a_1 t + \Psi w_t + u_t \quad \text{(A5.1)}$$

Where $\Phi(L) \equiv I_n - \Phi_1 L - \Phi_2 L^2 - \cdots - \Phi_p L^p$; L is the lag operator such that $L y_t \equiv y_{t-1}$; w_t is a $q x 1$ vector of exogenous I(0) variables, u_t is a $m x 1$ vector of unobserved disturbances. $\{\Phi_i, i = 1,2,\cdots p\}$ and Ψ are $m x m$ and $m x q$ coefficient matrices, respectively. The intercept and trend coefficients a_0 and a_1 are $m x 1$ vectors and t is a linear time trend. The unobserved disturbances are also assumed to satisfy the conditions: $E(u_t) = 0$; $E\left(u_t u_t'\right) = \Sigma$ for all t, where $\Sigma = \{\sigma_{ij}, i, j = 1,2\cdots,m\}$ is a $m \times m$ positive definite matrix, $E\left(u_t u_{t'}'\right) = 0$ for all $t = t'$ and $E(u_t | w_t) = 0$. The roots of $\left| I_m - \sum_{i=1}^{p} \Phi_i z_i \right| = 0$ satisfy $|z| > 1$ or $z = 1$

In view of the fact that most of the variables are expected to have deterministic trend, the estimation includes a trend. To avoid any quadratic trend in the solution for y_t, a linearity restriction is imposed by including it in the cointegrating vector. This also allows testing the significance of trend in the model. The intercept is kept unrestricted as it appears in VECM specification. With trend included in the vector of variables the coefficient matrix of cointegration will have a size of $(m+1)\times r$ and the estimated VECM is rewritten as follow:

$$\Delta y_t = a_0 - \alpha\beta_*'(y_{t-1}^*) + \sum_{i=1}^{p-1}\Gamma_i \Delta y_{t-i} + \Psi w_t + u_t \qquad \text{(A5.2)}$$

Here $y_{t-1}^* = (t, y_{t-1}')'$ and $\beta_* = \begin{pmatrix} -\gamma' \\ I_m \end{pmatrix}\beta$. The VECM is estimated by maximizing the log likelihood function of the VECM for a selected rank of $\Pi_* = \alpha\beta_*'$ which is equal to the number of cointegrating vectors. The number of cointegrating vectors is obtained by applying likelihood ratio tests on the maximum eigenvalue and trace of the stochastic matrix. The test statistics are computed in Pesaran et al. (2000). The structural estimation of the cointegrating relation requires maximization of a concentrated log-likelihood function subject to appropriate just-identifying or over-identifying restrictions on β. The procedure of identification is motivated by the desired long-run equilibrium properties of the underlying structural economic model.[65]

Annexure 5.4 Test results for cointegration between variables included in models AD1 and AD3

Maximum Eigenvalue Test					Trace Test				
Hypothesis		Statistic	Critical values		Hypothesis		Statistic	Critical values	
Null	Alternative		95%	90%	Null	Alternative		95%	90%
AD1: Variables included: y, m1, SBI, ipig5, Δp, reer, and Trend,									
r = 0	r = 1	49.46	43.61	40.76	r = 0	r = 1	139.61	115.85	110.6
r<= 1	r = 2	43.64	37.86	35.04	r<= 1	r<= 2	90.15	87.17	82.88
r<= 2	r = 3	16.84	31.79	29.13	r<= 2	r<= 3	46.50	63	59.16
r<= 3	r = 4	14.55	25.42	23.10	r<= 3	r<= 4	29.67	42.34	39.34
AD3: Variables included: y, m3, SBI, ipig5, Δp, reer, and Trend,									
r = 0	r = 1	51.73	43.61	40.76	r = 0	r = 1	144.59	115.85	110.60
r<= 1	r = 2	37.55	37.86	35.04	r<= 1	r<= 2	92.86	87.17	82.88
r<= 2	r = 3	26.27	31.79	29.13	r<= 2	r<= 3	55.31	63.00	59.16
r<= 3	r = 4	14.41	25.42	23.10	r<= 3	r<= 4	29.03	42.34	39.34

Note: The test for cointegration is done by applying likelihood ratio test on the maximum eigenvalue and trace of the stochastic matrix in VECM specification with restricted trend and unrestricted intercept (Pesaran, et al. 2000). The number of cointegrating vectors is indicated by 'r' in table below. Order of VAR is selected according to the order selection criteria based on SBC criteria of model selection.

[65] All the computations in respect of cointegration are conducted with the help of Microfit-4 software.

Annexure 5.5 Test results for cointegration between price and public sector wage

Maximum Eigenvalue Test					Trace Test					No. of vectors Selected
Hypothesis		Statistic	Critical values		Hypothesis		Statistic	Critical values		
Null	Alternative		95%	90%	Null	Alternative		95%	90%	
Model Ref. INFB1 & INFB2: Variables: p $wagp$ Trend; Period: 1973 – 98; Order of VAR = 2.										
Eigenvalues: 0.59893, 0.31562, 0.00										
r = 0	r = 1	23.75	19.22	17.18	r = 0	r = 1	33.61	25.77	23.08	1
r<= 1	r = 2	9.86	12.39	10.55	r<= 1	r<= 2	9.86	12.39	10.55	

Notes: The test for cointegration is done by applying likelihood ratio test on the maximum eigenvalue and trace of the stochastic matrix in VECM specification with restricted trend and unrestricted intercept (Pesaran, et al. 2000). The number of cointegrating vectors is indicated by 'r' in table below. Order of VAR is selected according to the order selection criteria based on SBC criteria of model selection.

Annexure 5.6 Structure of the cointegrating vector for modeling inflation with public sector wage

Model: INFB1 & INFB2: List of variables included in the cointegrating vector: p $wagp$ Trend,
Period: 1973- 98, Order of VAR = 2, Selected number of vectors =1.

Imposed Restriction: a1=1			
	p	$wagp$	Trend
Vector: a	1.000	-1.004	0.0472
Std. Error	(NONE)	(0.366)	(0.0460)
Imposed Restriction: a1=1; a3=0			
Vector: a	1.000	-0.6284*	0.000
Std. Error	(NONE)	(0.0097)	(NONE)

Log Likelihood (LL) subject to exactly identified restrictions (a1=1) = 96.011
LR test of additional restriction (a1=1; a3 = 0): CHSQ (1) = 1.507[0.22], LL subject to over identified restrictions = 95.257

Notes: The structure of the vectors is modeled according to the generalized restriction discussed in Pesaran and Smith (1998). Values in parenthesis () are standard errors. *significant at 1% level, **significant at 5% level and ***significant at 10% level.

Chapter 6

Money Demand Based Monetary Regime: Prospects and Pitfalls

6.1 INTRODUCTION

In the previous chapter an attempt was made to identify the inflationary process in the case of India and it was demonstrated that inflation in India is affected from both supply and demand side factors. Money growth significantly explains inflation. Slow adjustment of prices provides a stabilization role for monetary policy. However, the effectiveness of monetary policy in controlling inflation depends on the way it is conducted. The current monetary policy in India is mainly based on targeting broad money (M3) growth. A stable and predictable long-term relationship between monetary aggregates and a scale variable such as output has been a central requirement to monetary targeting. However, such a relationship has eluded several countries.

Amongst developed countries, several have switched from intermediate monetary targeting to a final inflation target, because of the observed instability of the demand for money function, leading to an uncertain relationship between monetary aggregates and the inflation rate. Thus, the developed countries began to abandon monetary targeting during the 1980s, conducting monetary policy through price variables like interest rates. With interest rates as the main channel of monetary transmission, open market operations (OMO) and announcements of official interest rates have become key instruments, which can be used to bring the market interest rate near target.

As was made clear in Chapter 1, in developing countries like India, where the interest rate is still far from market determined, the outcome of OMO can at most have only a partial effect and some control on monetary aggregates will still be required until such time as the interest rate channel is fully developed. With a monetary aggregate based monetary policy there are two possibilities. If inflation control is the major goal of the central bank, it can legitimately miss whatever target it fixes for money growth. Such a regime does not need precise function of demand for money. Instead, an inflation model, such as the one discussed in Chapter 5, can be a guiding model. A second alternative, which takes the form of a strict money growth targeting, requires a tight model of demand for money balance in terms of price, output, inflation and some measures of opportunity cost. As mentioned above, such a relationship has eluded several countries. Because the financial innovations radically change the portfolio behaviour of economic agents, leading to a breakdown of the relationship between monetary aggregates output and price.

Further, even with a stable demand function, Goodhart's Law[66] suggests that tightening or loosening monetary control loosens the relationship between money and the concerns of monetary authorities, particularly the stability of output. In a similar context another important, widely referred work is Lucas Critique (Lucas 1976). Poole (1970) suggested that when financial sector volatility (money multiplier shock or money demand shock) increases, interest rate oriented policy procedure is more desirable than monetary aggregate procedure.

However, research conducted by the RBI does not appear to support the view that such a possibility has occurred in India. The long run income elasticity of real broad money (M3R) in India is considered at about 1.58 (RBI 1998a: 34&69).

Nevertheless, there is an important question of whether the stock of money existing in the economy is a result of private sector demand or represents supply behaviour of the RBI. In the case of India, the notion that the stock of money is based on a meaningful function of private sector demand for money is doubted for two reasons. First, there is consistent high fiscal deficit (averaging around 8 percent of GDP during the sample period of 1970-98), which is financed either by money (the RBI buys government securities) or by debt (government borrows from public). In the first case, the monetary base increases directly, while in the second case the monetary base can also increase if the RBI has concern for an overshooting interest rate in the face of heavy government borrowing. Creation of such money directly or indirectly may not be based on the demand of real productive activity. However, it

[66] See Courakis (1981) and Evans (1985) for more details on Goodhart's Law.

can be argued that under an independent central bank with broad money target and no concern for the interest rate, there is no automatic link between fiscal deficit and monetary base, but it is hard to assume such independence for the RBI. Therefore, the influence of the fiscal deficit on the monetary base is examined in the following Chapter 7. Second, there is an obligation for commercial banks to supply about 40 percent of their credit to priority sectors, which may not be productively utilized. In such a situation, may what the RBI calls demand for money in reality be the supply of money based on rules of thumb?

In addition, financial sector reforms have now opened the economy to more means of finance and, hence, money market volatility is likely to increase. Therefore, how far the critical notion of sensible function of demand for money exists in India is an important question. If the demand function is not stable, it is important to correct the expectations of the prevailing monetary regime and flag the need for an alternative policy regime.

This chapter attempts to investigate whether there exists a meaningful demand function for money using three main monetary aggregates popular in the Indian economy. The key question is whether there is a meaningful robust and stable relationship between monetary aggregates and real output in the case of India? If not, what should be the alternative policy?

Three alternative approaches in the framework of long-term demand for money function are used to examine the relationship between money and output. The first approach uses simple static models of long-term functions, second the dynamic partial adjustment model and third the concept of cointegration for estimating the long-term relationships. Annual data for the period of 1970-98 have been used for the empirical analysis.

The rest of the chapter is organized as follows. The following section presents a brief review of recent studies with respect to demand for money in India. Section 6.3 discusses preliminary analyses of monetary aggregates such as velocity, and money multiplier. Section 6.4 examines demand for money functions and the relationship between money and output. Concluding remarks are presented in section 6.5.

6.2 A BRIEF REVIEW OF RECENT STUDIES ON DEMAND FOR MONEY IN INDIA

Past studies have analyzed demand for the two most commonly used monetary aggregates in India, narrow money M1, and broad money M3. The recent studies of the demand for money in India include Arif (1996), Joshi and Saggar (1995), Nag and Upadhyay (1993), and Moosa (1992). Moosa (1992) has modeled real currency in circulation, real narrow money, and real broad money (narrow money + quasi money) using quarterly data on industrial production index (IPI), and money market rate from 1972:1 to 1990:4.[67] Nag and Upadhyay (1993), modeled nominal narrow money using monthly data on IPI and yield on ordinary share from 1982:4 to 1991:1 and conclude that M1 is cointegrated with real economic activity.

Arif (1996), and Joshi and Saggar (1995) have used annual data from 1960-61 to 1992-93 and modeled real broad money (M3R) and real narrow money (M1R) using annual data. Both studies report stable long-term relationship between money and real output. However, these studies cover the pre-reform period only. Modeling base money (M0) with annual data has not been attempted in any of the known studies.

While modeling real money, these studies have assumed it does not depend on the price level, which implies demand for money means demand for real balance. With these assumptions, the partial adjustment models are estimated with lagged real balance instead of lagged nominal balance deflated by current price (see Arif 1996). Such maintained hypothesis is based on two assumptions. First, the price level elasticity of demand for the real balances is zero and second, that a change in the price level affects the demand for money without lag. These assumptions have been extensively scrutinized and contested in many studies, such as Goldfeld and Sichel (1987), and Spencer (1985). A second important aspect, which is found to be rather inadequately emphasized, is the role of inflation as the opportunity cost of money, particularly in view of the fact that interest rate variables have been found less informative.[68] Third, the monetary aggregates, price and output, are highly trended variables and may not necessarily be co-trended. Therefore, long-run relationships need to be scrutinized for spurious content through sensitivity analysis.

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[67] Moosa (1992) concludes currency in circulation and narrow money to be better aggregates for conducting monetary policy. However, the signs of the error corrections terms in his estimated equations are positive, which indicates that the estimated equations are unstable.

[68] Arif (1996) has used inflation as the opportunity cost but reports that the results were not satisfactory.

6.3 AN OVERVIEW OF MONETARY AGGREGATES

In this section, compositions of the three most commonly discussed monetary aggregates (base or reserve money M0, narrow money M1, and broad money M3) in India are examined and a brief analysis made with respect to the income velocity of these aggregates and money multipliers as a lead to the formal analysis of demand for money.

6.3.1 Definitions

Base money (M0) has four components: currency with the public (CUP), cash in hand of commercial banks (CIB), bankers' deposits (BDR) with the RBI, and other deposits with the RBI (ODR)[69]. Narrow money (M1) has three components: currency with the public (CUP), demand deposits (DD) with commercial banks and other deposits (ODR) in the RBI. Broad-money (M3) is the sum of M1 and time deposit (M3 = M1 + TD).

A broad picture of these components and money multipliers (MM3 and MM1), the statutory cash reserve ratio (CRR), the actual liquidity position of the banking sector represented by cash liquidity ratio (CLR), the statutory liquidity ratio (SLR), the currency with the public per person in nominal and real terms (CUPPP & CUPPPR) are presented in Table 6.1.

SLR represents banks' holdings of government securities. The major commercial banks were nationalized in 1969 and quantity controls like CRR and SLR imposed. The result can be seen in the sharp increase in BDR during the 1970s, which continued during the 1980s. With financial liberalization there was a reduction in CRR and SLR during the 1990s. However, looking at the values of CRR and CLR, it seems that banks tend to maintain more liquidity than statutorily required. Despite large increases in bank branches, the currency holding per person (CUPPP) in nominal terms as well as in real terms (CUPPPR) have considerably increased during the sample period. Incidentally, CUP constitutes a major part of narrow money, which as demonstrated in the previous chapter is causal to inflation.

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[69] 'Other' deposits with the RBI comprise mainly (i) deposits of quasi-government and other financial institutions including primary dealers, (ii) balances in the accounts foreign central banks and governments, (iii) accounts of international agencies such as IMF, (iv) provident, gratuity and guarantee funds of the RBI staff and some temporary accounts netted for balance under certain accounts, (v) profits of the RBI held temporarily under the deposit pending transfer to the central government.

Table 6.1 Components of monetary aggregates in India (1970-98)

	1970-71	1980-81	1990-91	1998-99	1970-98
Value in million rupee (end of period stock)					
M0=CUP+CIB+BDR+ODR	48230	194520	877790	2593450	
M1=CUP+ODR+DD	73740	234240	928920	3088010	
M3=M1+TD	110200	557740	2658280	9786330	
CUP = Currency with public	43710	134260	530480	1689700	
CIB = Cash in banks	1860	8810	22340	68760	
BDR = Banker's deposit with RBI	2060	47340	318230	797030	
ODR = Other deposits with RBI	600	4110	6740	37960	
DD = Demand deposits in banks	29430	95870	391700	1360350	
TD = Time deposits in banks	36460	323500	1729360	6698320	
Ratios					
Narrow money multiplier MM1= M1/M0	2.28	2.87	3.03	3.77	2.99
Broad money multiplier MM3 = M3/M0	1.53	1.20	1.06	1.19	1.26
CUP to Deposits	0.66	0.32	0.25	0.21	0.33
CRR = Cash reserve ratio (statutory)	0.03	0.06	0.15	0.10	0.09
CLR = (CIB+BDR)/(DD+TD)	0.06	0.13	0.16	0.11	0.12
SLR = Statutory liquidity ratio	0.28	0.34	0.38	0.25	0.33
CBDN = commercial bank density	48	21	14	15	22
CUPPP = CUP per person	81	199	636	1740	509
CUPPPR = real CUP per person	6	5	9	12	7
Component shares of M0					
BDR	4	24	36	31	25
ODR	1	2	1	1	1
CUP	91	69	60	65	70
CIB	4	5	3	3	4
Component shares of M1					
CUP	59	57	57	55	56
DD	40	40	42	44	43
ODR	1	2	1	1	1
Component shares of M3					
M1	67	42	35	32	43
TD	33	58	65	68	57
CUP	40	24	20	17	24
DD	27	17	15	14	19
Growth rate		1970-80	1981-90	1991-98	1970-98
M0		13.95	15.07	13.54	14.23
M1		11.56	13.78	15.02	13.34
M3		16.22	15.62	16.92	16.02
BDR		31.35	19.05	11.48	21.28
CUP		11.22	13.74	14.48	13.05
DD		11.81	14.08	15.56	13.69
TD		21.83	16.76	16.93	18.62

Notes: Aggregate data is the stock at the end of financial year (31 March). The ratios and shares are rounded-off as far as possible to avoid decimal places.

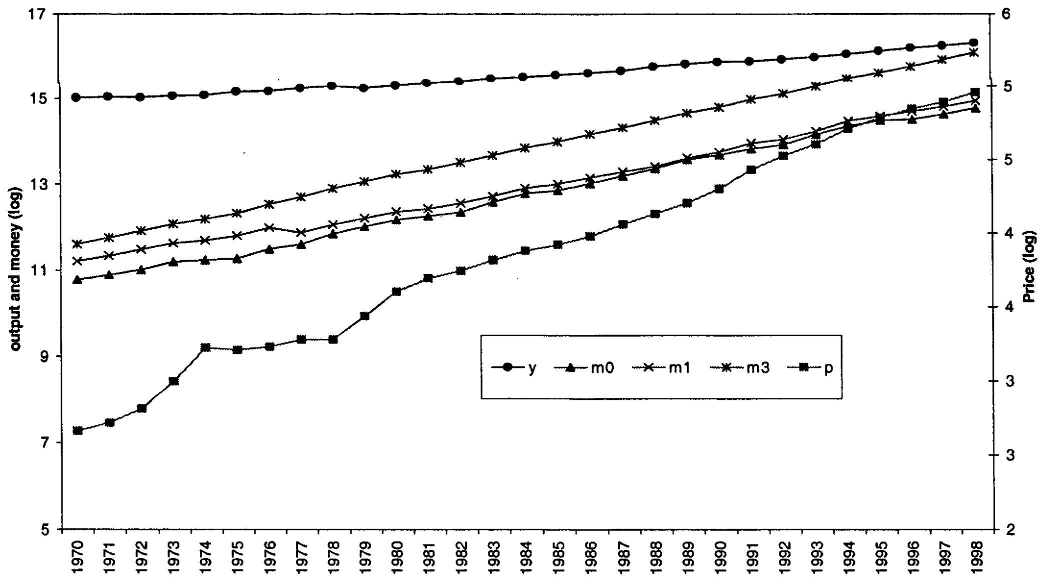
Source: See Appendix AA.

The RBI controls M0 through open market operations, auctions of treasury bills, and trading government securities. Thus, the central bank has relatively more control over base money than broad money and narrow money. However, the RBI has been more focused on broad money growth than base money growth. As observed by Vasudevan (1999), the money supply in India is not worked out on the basis of a money multiplier. As a result, high power money may not get its due importance in the final assessment of broad money stock. The system is distorted due to controls at both ends of the conduit. In this context, examining the behaviour of base money and narrow money are also important in order to get a better picture of the possibilities for monetary policy.

6.3.2 Growth of Monetary Aggregates

The monetary aggregates (in logs) along with the log level values of the price index and real output are plotted in Figure 6.1. Therefore, the slope of the curve indicates the growth rate. Clearly, these variables are highly trended but they do not appear to be co-trending, which is important for a meaningful long-term relationship. This point will be used in analyzing money demand later in this chapter. The average growth rate of monetary aggregates for a block of selected periods is presented in Table 6.1.

Figure 6.1 Trends of output, monetary aggregates (measured in millions of rupees) and wholesale Price index (1970-98)



Source: See Appendix AA.

During the sample period broad money M3 grew at a compound annual rate of about 16 percent. Narrow money M1 and the base money M0 have grown at an average rate of about 13 and 14 percent, respectively. This indicates that while the broad money multiplier has increased over time the narrow money multiplier has fallen down.

6.3.3 Time Series Properties of Monetary Aggregates and other Variables

All three monetary aggregates, the other relevant variables referred to earlier and to be subsequently used in estimation are tested for unit root using ADF test. The results are presented in Annexure 6.2 and summarized in Table 6.2. Since the dataset is small, SBC criteria of model selection has been used to decide the order of integration. As emphasized in Appendix AB of this thesis, too much emphasis cannot be accorded to the unit root property of the series in view of the fact that the dataset is small and the unit root tests are not very powerful with small samples. However, wherever there is doubt of a series being integrated due care is taken in estimations.

The test results clearly suggest all monetary aggregates are integrated of order one when taken in nominal values, while they trend stationary when taken in real values, probably because the price series itself is trend stationary. Output and interest rate variables of CGS1 and DR1, are all integrated of order one. For the purpose of analysis in this chapter a trend stationary series, which is not stationary in absence of trend, is treated as non-stationary, because when analyzed with other variables they may not all be co-trending.

Table 6.2: Summary of unit root test results for the variables used in Chapter 6

	Variables in levels		Variables in first difference	
	Unit root test with constant but no trend	Unit root test with constant and trend	Unit root test with constant but no trend	Unit root test with constant and trend
Nominal base money ($m0$)	I (1)	I (1)	I (0)	I (0)
Nominal narrow money ($m1$)	I (1)	I (1)	I (0)	I (0)
Nominal broad money ($m3$)	I (1)	I (1)	I (0)	I (0)
Real base money ($m0r$)	I (1)	I (0)	I (0)	I (0)
Real narrow money ($m1r$)	I (1)	I (0)	I (0)	I (0)
Real broad money ($m3r$)	I (1)	I (0)	I (0)	I (0)
Narrow money multiplier (MM1)	I (1)	I (1)	I (0)	I (0)
Broad money multiplier (MM3)	I (1)	I (1)	I (0)	I (0)
Price (p)	I (1)	I (0)	I (0)	I (0)
Real GDP (y)	I (1)	I (1)	I (0)	I (0)
Permanent income (yp)	I (0)	I (1)	I (0)	I (0)
Base money velocity (V0)	I (1)	I (1)	I (0)	I (0)
Narrow money velocity (V1)	I (1)	I (0)	I (0)	I (0)
Broad money velocity (V3)	I (1)	I (1)	I (0)	I (0)
Bank density (CBDN)	I (0)	I (1)	I (0)	I (0)
Fiscal deficit (CGAP)	I (1)	I (1)	I (0)	I (0)

	Variables in levels		Variables in first difference	
	Unit root test with constant but no trend	Unit root test with constant and trend	Unit root test with constant but no trend	Unit root test with constant and trend
Yield on 1-5 year govt. security (CGS1)	I (1)	I (1)	I (0)	I (0)
1-3 year deposit rate (DR1)	I (1)	I (1)	I (0)	I (0)
Call money rate (CMR)	I (0)	I (0)	I (0)	I (0)
Cash reserve ratio (CRR)	I (1)	I (1)	I (0)	I (0)

Note: All variables represented by small letters are taken in logs. The order of ADF test is chosen as 2 in all the cases based on SBC criteria of model selection. For the period beyond 1977, the narrow money multiplier MM1 is found to be stationary.

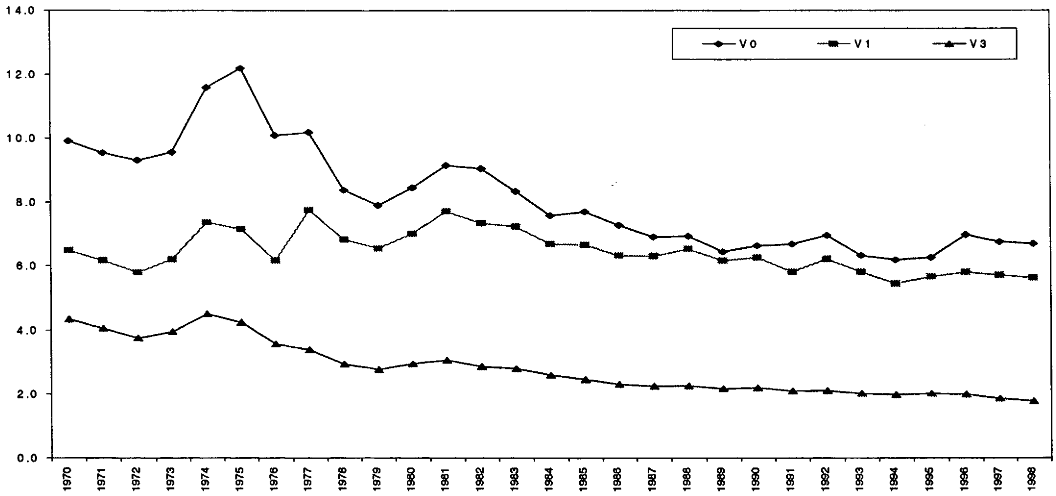
Source: Annexure 6.2 of this chapter. For basic data source see Appendix AA of the thesis.

6.3.4 Velocity and Money Multiplier

As pointed out earlier, the RBI has not been working through a multiplier. However, in view of the fact that the RBI continues to rely on the broad money growth target, it is important to know the nature of important variables like velocity and money multipliers. A plot of base money velocity V0, narrow money velocity V1, and broad money velocity V3, are presented in Figure 6.2, while the broad money multiplier MM3, and narrow money multiplier MM1, are presented in Figure 6.3. Velocities are calculated using relationship V = Y*(P/100)/M; where Y is real GDP at 1993-94 prices, P wholesale price index with base 1993-94 = 100, and M nominal stock of selected monetary aggregate. The broad money velocity and broad money multiplier both seem highly unstable throughout the sample period. This is not expected if the demand for broad money is to be a stable and robust function of income. The base money velocity has a falling trend indicating that the financial depth being acquired in terms of broad money creation is associated with too much liquidity, which may not be desired.

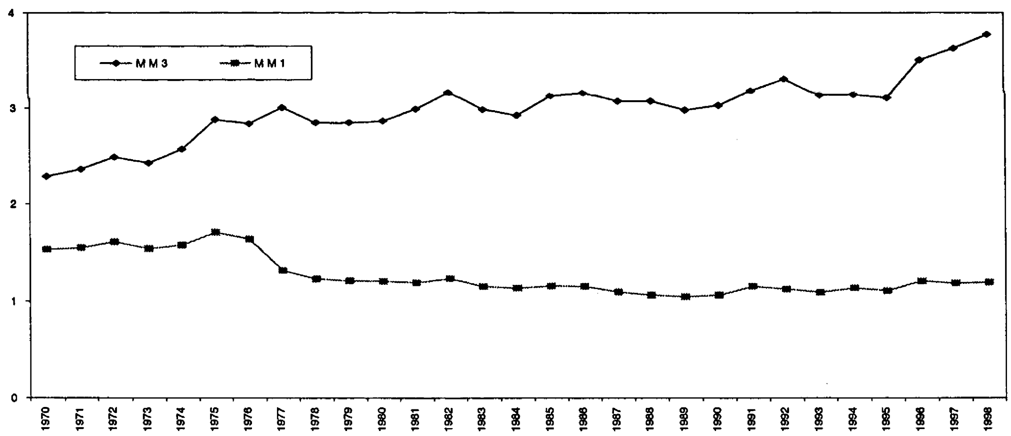
The ADF based unit root test results summarized in Table 6.2 (also see Annexure 6.2 for test statistics) indicate that MM3, MM1, V0 and V3 are all integrated of order one, while V1 could be considered stationary. For the period beyond 1977, the narrow money multiplier MM1 is also found to be stationary. The narrow money multiplier experienced a big reduction during 1972-1977, probably as a result of large-scale expansion of the banking sector during this period, which led to a massive fall in bank density (CBDN), measured as thousands of people per branch of commercial banks in the wake of nationalization of the banking sector.

Figure 6.2 Income velocities of money (1970-98)



Source: Calculated by author. For basic data source see Appendix AA

Figure 6.3 Money multipliers (1970-98)



Source: Calculated by author. For basic data source see Appendix AA

With a non-stationary multiplier and velocity, it is hard to control broad money and broad money stability is questioned in the first place. Mohanty and Mitra (1999) report only four occasions between 1983-97 when the RBI has been able to meet their broad money target. This is not surprising given the way V3 and MM3 are drifting.

The presence of a unit root in the money multiplier and velocity means that following any shock these variables will diverge infinitely without reverting to their mean. The Poole (1970) analysis presented in Chapter 3 suggests that when financial sector volatility (money multiplier shock or money demand shock) increases, interest rate oriented policy procedure is more desirable than monetary aggregate procedure.

However, the interest rate is still not fully market determined in India. The securities market is in the process of development. In such a situation, rejecting monetary aggregates would make monetary policy redundant, making it preferable for monetary aggregates to be chosen. At this stage, it appears narrow money has less problems than broad money.

6.4 MONEY DEMAND

The empirical work on money demand has a long history. Comprehensive reviews of several important works can be found among others in Laidler (1985), and Goldfeld and Sichel (1990). Studies of the demand for money usually start from a presumption that there exists a long-term equilibrium relationship between private sector money holding and certain other aggregate macro-economic variables, such as price levels, real income (or expenditure), (some set of) interest rates and, perhaps, wealth and the rate of inflation (Goodhart 1989:311). The relevant variables, to appear as arguments in this long-run relationship, can normally be chosen based on a priori theory, whether derived from Keynes' suggested motives, from Tobin-Baumol inventory theory or from Friedman's general portfolio choice model.

The theoretical literature, which draws from the Keynesian tradition, has identified the three most important motives for holding money. (1) The transaction motive, which is the demand for money in making regular payments, (2) the precautionary motive, which is the demand for money to meet unforeseen contingencies, and (3) the speculative motive, which arises from uncertainties about the money value of other assets, an individual can hold. Baumol (1952) and Tobin (1956) applied an inventory theoretic approach to the transaction motive while Tobin (1958) applied mean variance analysis to model money as an asset. Friedman (1956) provided an intuitive account of the demand for money which attempts to unify the two streams – the asset and transactions approach. In his analysis, the cost to a business enterprise of holding money can be represented by such variables as yields on the bond, market interest rate on equity, expected capital gains and average expected inflation. The service flow from money can be defined in terms of price P, the amount of goods, which can be bought with one unit of domestic currency. Friedman (1956) stressed money as a store of wealth, which led him to include a measure of wealth in the demand for money function. A discounted infinite stream of income could proxy wealth or, alternatively, current real income could also proxy wealth.

Uncertainties about the returns on risky assets lead to diversification of the portfolio held by an individual. Savings and time deposits, being safer assets, are affected by the risk assessment of the other portfolios. Thus, broad money, which contains time deposits, is more affected by speculative and precautionary motives, while narrow money and base money are more affected by transaction and precautionary motives. Therefore, theories that posit money yields some unspecified flow of services beyond the transaction motive rely on broader aggregates.

Thus, in order to capture the theoretical motives of holding money, the empirical literature has identified four groups of variables. The first group is widely known as the scale variable, which generally proxy for the volume of transactions in the economy. A measure of wealth, income, or expected income, is used to represent the scale variable, which forms an important independent variable in most conventional demand functions for money. Laidler (1985:88) has discussed error-learning hypothesis[70] as a plausible alternative of measuring expected income, which can be used as potential income.

The second group of variables represents the opportunity cost of holding money. Uncertainties associated with the level of payments guide individuals to keep precautionary money to maintain an adequate level of liquidity for day-to-day requirements. Maintaining this liquidity is costly, because it requires foregone returns that would have otherwise been earned. Variables that represent such costs as the interest rate, yields on assets other than money, the yields on money itself, and

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[70] The error-learning hypothesis implies that the expected future value of a variable can be measured by taking an exponentially weighted average of current and past values of that variable, which assumes people take more notice of the recent past than the distant future. With this idea, in this study, a 50% weight is given to current income while the balance of 50% is exponentially distributed over the past 10 years such that the sum of the weights equal approximately one. The measure of this income can also be called permanent income represented by YP.

expected inflation, fall into the category of opportunity cost. In an open-economy context exchange rate represents the opportunity cost for holding foreign money. The third group of variables, representing the level of wages and the riskiness of bonds, can also find place in the function for demand of money.

The fourth group of variables includes technological variables representing transaction technology. Goldfeld and Sichel (1990:324) note that most of the evidence on the effects of financial innovation is rather indirect, using trend to capture exogenous technological change or some function of the previous peak interest rate as a proxy for an endogenous reduction in transaction costs.

Issues related to the choice and measurement of proper opportunity cost as an important aspect of designing the money demand function have been emphasized in the literature. This problem is more complex for developing countries due to underdeveloped financial markets. In such counties, households or firms may prefer to hold their wealth in stocks of food, houses or machinery, rather than in financial assets, to avoid the cost of inflation. The public is reluctant to hold assets such as long-term and short-term bonds when inflation is expected unless the rate of return is adjusted upward to compensate for the expected erosion of real-capital value brought about by inflation.

In a well-developed competitive capital market, interest rates, particularly the term structure, will reflect inflation expectations, and hence it will not make much difference whether the alternative cost of holding money is measured by the interest rate or the inflation rate. Thus 'to include the rate of return in a nominal asset in the demand-for-money function is thus to include a measure of the expected inflation rate therein. Moreover, the measure in question is produced by market forces, and its reliability does not depend on any particular hypothesis about how inflation expectations are formed' (Laidler 1985:96). However, 'when capital markets are not free because interest rates are regulated or have ceilings, it is often appropriate to use inflation, not interest rate as the measure of the alternative cost' (Dornbusch and Fischer 1994:388).

In order to formalize a close economy version of the demand for money function in this section the following general expression is considered for demand of nominal money based on Laidler (1985:136). However, the expression is different to Laidler in some respects, because it includes a trend and because the set of opportunity costs include inflation in addition to interest rates. The interest rate and inflation are taken in fractions.

$$M_d = Ae^{\alpha t} P^{\beta_1} X^{\beta_2} e^{\beta_3 R_1} e^{\beta_4 R_2} e^{\beta_5 \Delta p} \quad (6.1)$$

Here, A is a constant, t is time, M is the amount of the monetary aggregate demanded, P is the price level, X is the scale variable, and R1 is own interest rate of money such as deposit rate, R2 is a vector of the interest on the alternative asset, Δp is inflation expressed in a fraction. The exponential e has a value of 2.7183. α, β1, β2, β3, β4, β5, are parameters.

The early work in industrialized countries has almost established the following properties of money demand (Dornbusch and Fischer 1994: 385-388). (1) The demand for a nominal money balance is proportionate to the price level. There is no money illusion; in other words, the demand for money is a demand for real money. (2) The demand for real money responds negatively to the rate of interest on alternative assets like treasury bills, commercial papers and money market instruments, but it responds positively to its own rate of return, like the rates paid on various kinds of deposits. (3) The demand for money increases with the level of real income. (4) The short-run response of money demand to changes in interest rates and income is less than the long-run response.

Thus, in terms of signs, β1, β2, β3 are expected to be positive, and β4 and β5 are expected to be negative. What should be the sign of α? Developed institutions and efficient means of financial transaction may lead to a fall in the demand for money. In that case α should be negative. However, as discussed in Chapter 1, in the context of developing countries like India there are large amounts of directed credit for certain priority sectors like agriculture, food, self-employment and small business. The financial institutions fulfill this welfare motive by adopting a policy that ensures an easy and preferential credit policy for these sectors. The trend term is expected to capture such effects as well as the technological and discretionary effects. However, with positive and significant α, the long-term stability of demand function for money itself can be seriously questioned. Therefore, presence of trend in the model serves important aspect of specification search.

Dividing equation (6.1) throughout by price, the expression for the real money balance can be arrived at as follows.

$$\frac{M_d}{P} = Ae^{\alpha t} P^{(\beta_1 - 1)} X^{\beta_2} e^{\beta_3 R_1} e^{\beta_4 R_2} e^{\beta_5 \Delta p} \tag{6.2}$$

Taking log of both sides of equations (6.1) and (6.2), and representing the logged variables in their lower case letters, the nominal and real money balances can be expressed as equations 6.3 and 6.4 respectively. A Δ before a variable represents that the variable is taken in the first difference.

$$m = a + \alpha\, t + \beta_1\, p + \beta_2\, x + \beta_3\, R1 + \beta_4 R2 + \beta_5 \Delta p \tag{6.3}$$

$$m - p = mr = a + \alpha\, t + (\beta_1 - 1)\, p + \beta_2\, x + \beta_3\, R1 + \beta_4 R2 + \beta_5 \Delta p \tag{6.4}$$

It can be noticed that the demand for real balance depends on price if $\beta_1 \neq 1$. In case β1=1 then the demand for money is in fact the demand for real balance. With β1=1 equation (6.4) can also viewed as a somewhat simplified linear form of the demand for money equations (7) and (11) of Friedman (1956:9).

For a given data set, if $\beta_1 \neq 1$; omission of the price variable from regressors may show itself in instability and poorness of fit in any test that uses data measured in real terms (Laidler 1985:136). Spencer (1985) addressed this problem in a framework of partial adjustment model and could not reject the hypothesis of zero price elasticity of real money but could reject the hypothesis that there is an instantaneous adjustment to price changes in the demand for real balance. Therefore, it would be preferable to test in the regression results whether β1 equals one or not. The problem of instantaneous adjustment would subsequently be taken up in the subsection on dynamic models. An estimation equation of the form of equations (6.3) or (6.4) provides long-term relationships between the dependent and independent variables.

For the purpose of empirical analysis the scale variable is alternatively represented by the gross domestic product (Y) and permanent real income (YP) as defined in Chapter 4. The three monetary aggregates M0, M1 and M3 are already defined. Interest rate on 1-3 year deposits in commercial banks (DR1) proxy the own rate of return of money. The opportunity cost represented by yield on 1-5 year treasury bills (CGS1) proxy rate of return on alternative assets, and inter-bank call money rate (CMR) is an indicator rate of liquidity position in banking sector. DR1, CGS1 and CMR are all expressed in fractions. The price is represented by the wholesale price index (P). Inflation, also in fractions, is represented by Δp. Except for CGS1, DR1, CMR and Δp, all other variables are taken in natural logs, written in lower case letters. A data summary is provided in Annexure 6.1 of this chapter and more details about the sources and description of the variables are presented in Appendix AA of the thesis.

The ADF tests of unit root for the variables are presented in Annexure 6.2 of this chapter and summarized in Table 6.2. Except for inflation and CMR, all of these variables, including the three monetary aggregates, are integrated of order one in the absence of trend while their differences are stationary. Inflation and CMR are stationary.

6.4.1 Simple Static Models of Long Run Relationship

Starting with a simple model of demand for money function with output and real money, additional variables are systematically added in the list of regressors in accordance to equation (6.4) in order to test the robustness of the output variable.[71] The regression results are presented in Tables 6.3. It may be noted that the results of Tables 6.3 are only a partial list of the possible combinations of the various variables that can find a place in a function of the demand for money. The focus is on the variable y, which is the log of real output.

To take care of the serial correlation problem if any, the estimation is done by maximizing the likelihood function with the Cochrane-Orcutt (CO) method of iterative adjustment (see note on CO method in section AB.5 in Appendix AB). The order of the AR process in the residuals reported in Tables 6.3 is selected according to the Durbin Watson statistics[72]. In order to exercise caution regarding the validity of the regressions, the residuals of the regressions were examined for stationarity but the same is not reported. The P-values are reported in square brackets for all variables. In cases where OLS estimates are free from first order serial correlation, the same are reported.

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[71] Such a method of sensitivity analysis is widely used for testing the robustness of a particular variable in regression equations (see Leamer (1985), Levine and Renelt (1992), Sala-i-Martin (1997)).

[72] It may be noted tat the Durbin Watson statistics is valid for AR(1) process. However, when there is first order autocorrelation the test statistics can be used even with second order autocorrelation.

Several important conclusions can be drawn from the simple money demand equations estimated in Tables 6.3. However, before proceeding, it is important to note the belief of the RBI about the long run income elasticity of real broad money (M3R), which is considered to be about 1.58 (RBI 1998a: 34 & 69). Arif (1996) estimated long run income elasticity for real broad money (M3R) and real narrow money (M1R) at about 1.7 and 1.1, respectively. The results of the simple estimation of demand for real broad and narrow money presented at rows 1 and 13, respectively in Table 6.3 suggest income elasticities of 1.52 and 1.15, respectively, which are quite close to the above results, significant at the one percent level. However, the question of how robust these estimations are is addressed in the remainder of this chapter.

Looking at the coefficients and significance level of the variable y in Table 6.3, it clearly comes out to be a fragile variable for all three aggregates particularly when trend is included in the list of explanatory variable. Output is fragile in the broad and base money equations even without trend. Therefore, the contention of the earlier studies, that broad money is an especially stable function of output, is not fully supported in this exercise. It can be noted from Table 6.3 that in absence of trend, there is no perceptible change in the explanatory power of the models due to the inclusion of other variables, even when significant. This points to an important missing variable, being captured by some of the existing variables. It can be recalled that output, price and money are all highly trended. Therefore, models with some role of trend are expected to have more information. Trend in almost all the models of Table 6.3 is highly significant and positive, which on its own can explain between 0.98 and 0.995 in sample variation in monetary aggregates.

It can be emphasized that either an insignificant coefficient of trend or a coefficient with negative sign would have been expected in order to accept these models as equations of the demand for money. Only in the case of narrow money the trend becomes insignificant in a particular specification presented at row 17 in Table 6.3. What does a positive and significant trend mean in the money equation?

Table 6.3 Simple long run functions of real balances estimated using Cochrane-Orcutt method of adjustment for serial correlation if any (1970-98)

Dependent Variable	Regressors						Autoregressive Error		R^2	Serial Correlation	
	Const.	p	y	CGS1	Δp	T	U(-1)	U(-2)		DW	LM1
m3r											
1.	-13.65		1.52				0.75		0.992	1.61	
	[0.00]		[0.00]				[0.00]				
2.	-12.16	0.148	1.385				0.948	-0.39	0.992	1.87	
	[0.005]	[0.45]	[0.00]				[0.00]	[0.06]			
3.	-11.71	0.16	1.35	0.31			0.939	-0.40	0.992	1.88	
	[0.01]	[0.43]	[0.00]	[0.75]			[0.00]	[0.06]			
4.	2.00	0.81	0.31	0.57	-0.76		0.98	-0.70	0.993	2.21	
	[0.69]	[0.00]	[0.41]	[0.43]	[0.02]		[0.00]	[0.00]			
5. #	14.06	-1.32	-0.12	-0.43	0.257	0.195			1.000	1.77	0.38
	[0.00]	[0.00]	[0.17]	[0.01]	[0.00]	[0.00]					[0.54]
6.	8.74					0.082	0.876	-0.55	0.995	2.40	
	[0.00]					[0.00]	[0.00]	[0.00]			
m0r											
7.	-12.22		1.36				0.65		0.983	1.64	
	[0.00]		[0.00]				[0.00]				
8.	-14.38	-0.13	1.53				0.678		0.983	1.73	
	[0.00]	[0.62]	[0.00]				[0.00]				
9.	8.82	-0.86	0.51	-1.25			0.96		0.988	1.79	
	[0.49]	[0.01]	[0.34]	[0.15]			[0.00]				
10.	-1.50	-1.42	1.27	-1.26	0.92		0.97		0.992	2.34	
	[0.89]	[0.00]	[0.02]	[0.09]	[0.00]		[0.00]				
11.	10.94	-1.49	0.053	-0.44	0.711	0.19	0.40		0.994	1.83	
	[0.07]	[0.00]	[0.89]	[0.43]	[0.01]	[0.00]	[0.11]				
12.	7.79					0.071	0.061		0.985	1.61	
	[0.00]					[0.00]	[0.00]				
m1r	Const.	p	y	DR1	Δp		U(-1)	U(-2)			
13.	-8.867		1.15				0.431		0.978	2.05	
	[0.00]		[0.00]				[0.02]				
14. #	-16.30	-0.35	1.72						0.981	1.67	0.73
	[0.00]	[0.02]	[0.00]								[0.40]
15. #	-16.68	-0.44	1.75	2.90					0.983	1.62	0.91
	[0.00]	[0.00]	[0.00]	[0.11]							[0.34]
16. #	-20.79	-0.66	2.06	3.87	0.63				0.986	1.93	0.02
	[0.00]	[0.00]	[0.00]	[0.03]	[0.02]						[0.88]
17. #	-18.04	-0.82	1.90	4.11	0.67	0.02			0.987	1.76	0.43
	[0.00]	[0.01]	[0.00]	[0.02]	[0.01]	[0.43]					[0.51]
18.	18.49	-1.21	-0.52	3.36		0.19	0.89		0.988	2.45	
	[0.01]	[0.00]	[0.24]	[0.02]		[0.00]	[0.00]				
19.	8.13					0.063	0.732		0.977	2.37	
	[0.00]					[0.00]	[0.00]				

Note: Values in square bracket [] are the P-values. Period of estimation: 1970-98 except when inflation is included it is 1971-98. Equations marked # are estimated by OLS as there was no indication of first order serial correlation problem.

Consider the broad money. With trend in the equations, the coefficients of the price variables are slightly more than one, with negative sign. Considering that the average change in price during the sample was about 0.082, it is easy to calculate the autonomous growth in the nominal broad money stock at around 17 percent. The coefficient of the output term is insignificant and negative. The negative sign suggests that whenever a slow down is observed the central bank tries to induce credit creation and thus increase money stock. Actual average M3 growth for the period 1971-98 has been 16 percent, which is consistent with about 5 percent output growth. When output growth tends to fall below this level, the money growth is increased in excess of 16 percent. When output growth is in excess of five percent the central bank seems to be concerned about a possible increase in inflation and thus money growth is brought below 16 percent. However, this represents reaction or supply side behaviour of the RBI and the existence of any demand-based behaviour is questionable.

The equations for base money also in Tables 6.3, point to a limited role for output in determining its long-term demand. However, output seems to be more robust in equations for narrow money.

There is no conclusive answer to the question of price elasticity of real balances. In most its coefficient is significant, so that assuming $\beta 1=1$ in equation (6.2) may lead to the problem of a missing variable in demand for real balances and estimation of nominal money with price as one of the explanatory variables may be a more general estimate. It can be noticed that $\beta 1=1$ is rejected in almost all models containing trend. However, a negative coefficient of more than one of price term suggests that inflation is significant restraint in money supply by the RBI.

In view of the fact that the macroeconomic variables are expected to have lagged effects, the above analysis needs to be supported with dynamic analysis. Therefore, role of output is investigated in partial adjustment models and cointegration framework in the following subsections in this chapter.

6.4.2 Long Term Analysis in Dynamic Model with Partial Adjustment

Despite several shortcomings, the partial adjustment mechanism (PAM) has often served as the workhorse to capture the underlying dynamics of short-run money demand (Goldfeld and Sichel 1987). Two alternative PAMs have been utilized in the literature, called real and nominal models. The primary difference between these two specifications is the way in which adjustment in money demand is considered with respect to changes in prices. The real model implies there is an instantaneous adjustment of money balances to changes in the price level, whereas the nominal model posits that this adjustment is subject to a distributed lag. Both versions of partial adjustment models are motivated by an underlying cost function as the one discussed in Hwang (1985).

In particular, under the real partial adjustment mechanism (RPAM), the equation for real balance has the lagged nominal money balance deflated by the lagged price level, whereas in the nominal partial adjustment mechanism (NPAM) the equation for real balance has the lagged nominal balance deflated by the current price level (see Spencer 1985). Given the difference, there has been substantial literature on formal comparison of the two models (see for example Goldfeld and Sichel (1990), Goldfeld and Sichel (1987), Spencer (1985), Goldfeld (1973)). As both specifications suffer from problems, Goldfeld and Sichel (1987) suggested a general distributed lag model of the form of equation (6.5), which may be a better representation of the dynamic behaviour of demand for real balance. All the symbols in equation (6.5) are the same as discussed earlier. Coefficients are represented by a, b, c and d. R is a vector of interest rates, y is log of real output, p is log of price level, m is log of nominal money, and mr represents real money balance.

$$mr = m - p = a + \sum_{i=0}^{n1} a_i y_{t-i} + \sum_{i=0}^{n2} b_i R_{t-i} + \sum_{i=1}^{n3} c_i mr_{t-i} + \sum_{i=0}^{n4} d_i p_{t-i} + \varepsilon_t \qquad (6.5)$$

Goldfeld and Sichel (1987) argue that with the above specification the real balance is no longer constrained to adjust with the same geometric distributed lag to each independent variable. After rewriting the equation (6.5) to include inflation terms, it is also possible to test short-run and long run inflation effects. Finally, this equation is not motivated by any underlying cost function, as are NPAM and RPAM, and is therefore not intended to shed light on the preferred adjustment process. With these backgrounds, the above equation is estimated for the Indian data to obtain dynamic models of demand for real balances and to examine whether there is a stable relationship between money and output in the long term.

Three interest rate variables, namely the interest rate on 1-3 years demand deposits (DR1), the yield on 1-5 years government securities (CGS1), as used earlier and the overnight call money rate (CMR) are selected for this experiment. However, only those interest rate variables, which give rise to relatively better specification of the models, are retained instead of all three. All three monetary aggregates are again modeled in the above specification. After a little experimentation, a one period lag is found to give a statistically preferred specification. The estimated equations are presented in Table 6.4. To safeguard against unit root problem the residuals are tested for stationarity and the ADF test statistics are presented. After reparameterization and removing the insignificant variables, the parsimonious models are presented in Table 6.6. The equations are tested for stability of coefficients and predictive failure after breaking the sample as indicated in the Tables. The results are satisfactory. Further, CUSUM of recursive errors and CUSUM of squared recursive errors tests (not shown here) do not show any structural break. Some important conclusions can be drawn from the estimated results.

First, output is a completely insignificant variable in the case of broad and base money, but not for narrow money. As discussed earlier, permanent income is also not found significant in the case of broad and base money. The income elasticity calculated and presented in Table 6.5 is not significantly different from zero in both cases. Thus, based on this specification, again, the existence of equation of demand for broad as well as base money is questionable. Second, the coefficient of lagged money in the case of base money as well as broad money is not different from one (see the test statistics in Table 6.4 and 6.5). This means only a short-term adjustment is taking place and equilibrium money stock is undefined. This is in line with the argument presented earlier that there is trend growth in money supply with some adjustment rather than demand based supply. Third, as can be seen from the parsimonious results presented in Table 6.5, inflation is a relevant opportunity cost for both real broad and real base money. It explains most of the variation in these aggregates, particularly the broad money. Fourth, in the partial adjustment framework base money and broad money demonstrate homogeneity with respect to price.

However, in the case of narrow money M1, there is sufficient indication of existence of a possible function of demand for real balance and it does not demonstrate homogeneity with respect to price unlike broad and base money noted earlier. The parsimonious version of the narrow money demand presented in Table 6.5 has satisfactory statistical properties. The long-term income elasticity of narrow money is around 1.87, which can be considered on the high side. With less developed means of financial transactions, higher income elasticity is not surprising.

Table 6.4 Dynamic models of demand for monetary aggregates with partial adjustment (1971-98)

Dependent Variable	Real broad money ($m3r$)	Real base money ($m0r$)	Real narrow money ($m1r$)
Model number	M3RPA1	M0RPA1	M1RPA1
INTERCEPT	0.550 (0.664)	0.716 (4.06)	-12.72 (1.63)**
$m3r$ (-1)	1.065 (0.065)*		
$m0r$ (-1)		1.033 (0.198)*	
$m1r$ (-1)			0.379 (0.227)
y	-0.189 (0.204)	-0.223 (0.705)	0.420 (0.513)
y (-1)	0.132 (0.189)	0.170 (0.508)	0.847 (0.388)**
p	-1.254 (0.115)*	-1.191 (0.364)*	-0.613 (0.300)**
p (-1)	1.223 (0.118)*	1.181 (0.394)*	0.228 (0.413)
CGS1	-0.344 (0.316)	-1.151 (0.890)	
CGS1 (-1)	0.405 (0.318)	1.494 (0.877)	
DR1			5.688 (1.71)*
DR1 (-1)			-2.250 (2.03)
CMR			-0.710 (0.380)***
CMR (-1)			-0.206 (0.398)
R-Square	0.999	0.991	0.993
R-Bar-Square	0.999	0.987	0.990
S.E of Regression	0.024	0.066	0.048
Diagnostic Tests			
DW (h) -statistics	- 1.57 (0.116)	Undefined	Undefined
LM (3) serial correlation	6.06 [0.11]	2.80 [0.42]	1.46 [0.69]
ARCH (3) test	0.65 [0.89]	0.54 [0.91]	1.75 [0.63]
Functional Form CHSQ (1)	2.45 [0.12]	14.6 [0.00]	1.06 [0.30]
Normality CHSQ (2)	0.86 [0.65]	0.80 [0.67]	0.39 [0.82]
Predictive failure CHSQ (6)	6.02 [0.42]	16.01 [0.01]	6.44 [0.38]
Stability test CHSQ (8)	6.97 [0.54]	23.98 [0.00]	
Stability test CHSQ (10)			6.29 [0.79]
Residual Unit root test			
Test statistics (DF)	-7.20	-5.16	-5.14
Functions and Restrictions			
Income elasticity a=(a3+a4)/(1-a2)	0.89 (1.27)	1.629 (6.81)	2.04 (0.280)*
Coeff. of lagged money a2=1 CHSQ (1)	0.990 [0.32]	0.027 [0.87]	7.46 [0.006]

Notes: Predictive failure test and parameter stability tests are conducted by breaking the sample at 1992; when the number of regressors in the model exceed five then the stability test is conducted by breaking the sample at nearest past as permitted by the number of regressors in the equation. Unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Table 6.5 Dynamic models of demand for monetary aggregates with partial adjustment: parsimonious version (1971-98)

Dependent Variable	Real broad money ($m3r$)	Real base money ($m0r$)	Real narrow money ($m1r$)
Model number	M3RPA1	M0RPA1	M1RPA1
INTERCEPT	0.152 (0.068)**	0.125 (0.190)	-13.29 (2.48)*
$m3r$ (-1)	1.002 (0.007)*		
$m0r$ (-1)		1.003 (0.021)*	
$m1r$ (-1)			0.272 (0.125)**
y (-1)			1.362 (0.233)*
p			-0.402 (0.098)*
Δp	-1.142 (0.086)*	-1.079 (0.233)*	
DR1			4.807 (1.600)*
CMR			-0.763 (0.358)**
R-Square	0.999	0.989	0.991
R-Bar-Square	0.999	0.988	0.989
S.E of Regression	0.023	0.063	0.049
Diagnostic Tests			
DW (h) -statistics	-0.76 (0.445)	-0.13 (0.90)	-0.292 (0.77)
LM (3) serial correlation	3.19 [0.36]	3.58 [0.31]	1.97 [0.58]
ARCH (3) test	0.88 [0.83]	1.21 [0.75]	1.35 [0.72]
Functional Form CHSQ (1)	0.60 [0.44]	2.81 [0.09]	0.25 [0.62]
Normality CHSQ (2)	0.45 [0.80]	0.74 [0.69]	0.74 [0.69]
Predictive failure CHSQ (6)	6.91 [0.33]	0.65 [0.37]	9.36 [0.15]
Stability test CHSQ (3)	3.50 [0.32]	4.69 [0.20]	
Stability test CHSQ (6)			9.36 [0.15]
Residual Unit root test			
Test statistics (DF)	-5.89	-5.09	-5.44
Functions and Restrictions			
Income elasticity			1.87 (0.20)*
Coeff. of lagged money a2=1 CHSQ (1)	0.086 [0.769]	0.016 [0.980]	33.86 [0.00]

Notes: All notes of Table 6.4 apply.

The above results are broadly consistent with the analysis made so far and the inferences drawn based on the behaviour of money multipliers and velocities. However, in view of the fact that major variables are integrated of order one, it is important to test the long-run relationship in a cointegration framework, and this is attempted in the following subsection. In view of the conflicting results about the existence of homogeneity conditions with respect to price, the monetary aggregates will be taken as nominal quantities with price as an independent variable in order to let it take the value most appropriate from the data.

6.4.3 Cointegration Approach to Long Term Relationship

An (n x 1) vector time series y_t is said to be cointegrated if each of the series taken individually is I(1), that is, nonstationary with a unit root, while some linear combination of the series $a'y_t$ is stationary or I(0) for some nonzero (n x 1) vector a.

This means that while each of the series may wander arbitrarily far from the starting value due to permanent changes caused by many developments in individual series, there is some long run equilibrium relationship tying them together represented by the linear combination $a^{'}y_t$. Taking advantage of the I(1) nature of most time series variables, in the recent literature the properties of cointegrating vectors are extensively exploited to study the long run relationships. The test procedure of cointegration followed in this chapter is the same as described in Annexure 5.3 of Chapter 5. More description of a cointegrated vector error correction model (VECM) with generalized restrictions for empirical analysis is provided in Appendix AB of the thesis.

The advantage of this method is exploited in this chapter for testing the existence of demand for money function under two previously mentioned conditions. These are restated as follows. (1) Whether output appears in the long run relationship according to the expectations and (2) whether the variables included in the functions for money are co-trending with money or not, and, if not, whether the trend is negative or positive. With a significant positive trend in the function for money and or insignificant or negative coefficient of output, the data generating process cannot be considered to emerge from a long-term function of demand for money.

The test results of cointegration under the procedure discussed above are presented in Annexure 6.3. and the emerging long run relationship between the variables is summarized in Table 6.6. Realizing that the cointegration results are sensitive to the order of VAR, it has been selected using a statistical technique of SBC criteria of model selection. Three sets of results are produced for each of the nominal monetary aggregates, which include simple relationships between money, price and output and between money, price, output, own return on money and return on government bonds. Trend is included in all experiments and the test statistics of its significance is also presented in Table 6.6.

The cointegration analysis requires all variables to be integrated of the same order, however, in practice, it is hard to find the relevant economic variables to comply with this requirement (Engle and Granger 1987). Johansen (1995), allows the I(0) variable to be used in cointegration analysis with other I(1) variables, while Granger (1997) cautioned against resulting complications in interpretation and Levtchenkova, et al. (1998) argue that inclusion of I(0) variables may result in loss of information. Therefore, as far as possible, this thesis avoids such mixing. The variables used for present cointegration analysis are all I(1) with or without trend except the price variable which is I(1) with intercept and no trend but it is stationary with intercept and trend (see Table 6.2).

The results from Table 6.6 are all in line with the conclusions made in earlier analysis. While the important variables are cointegrated, there is sufficient indication to infer that the long term relationships in regards to the equations for broad and base money are not demand for money functions. The test that the cointegrating variables are co-trended is rejected at all levels of significance. Second, the trend is significantly positive which indicates autonomous growth in money supply. Third, the coefficient of output variables is either insignificant or negative, which again reflects that these functions are reaction functions around some trend growth rate of money as discussed earlier. In view of this and all the earlier findings, it can now be concluded that demand for broad and base money is undefined in the case of India and should not be a basis for conducting monetary policy. Nevertheless, an effort is made in Chapter 7 to estimate a behavioural equation for the supply of broad and base money.

However, the case of narrow money M1 is different, where there is indication of a better-specified function for the long-term demand for narrow money. Therefore, further discussion on the demand for money will be confined to narrow money only. In all three formulations of narrow money in Table 6.6 (lines 7-9), output is significantly positive and trend is either insignificant or significantly negative. The negative sign of trend can have an interpretation in terms of technological effects, which reduces cash holding with respect to output growth. The signs of own rate of return (DR1) and returns on bonds (CGS1) are also as expected in the demand for money equation. It may be noticed that the long-term income elasticity of narrow money lies between 2.2 and 2.4, which is higher than the earlier estimate of 1.7 done in the tradition of partial adjustment. But how much this long relationship will be useful in explaining the short-term adjustment of narrow money demand is another vital issue that will be examined in the following discussion.

Table 6.6 Summary results of cointegration tests for variables in alternative specifications of demand for nominal money balances (1971-98)

No.	Variable set	VAR order	Max eigen-value test	Trace test	Long-term relationship	LR Test for coefficient of trend CHSQ(1)
M3	Nominal broad money					
1.	m3, y, p & T	1	no	yes	m3 = -0.067 y – 0.201 p + 0.181 T* + e1 (0.11) (0.13) (0.012)	4.930 [0.026]
2.	m3, y, p, CGS1 & T	1	yes	yes	m3 = -0.12 y***– 0.346 p* - 0.439 CGS1* + 0.205 T* + e2 (0.06) (0.069) (0.111) (0.008)	25.77 [0.00]
3.	m3, y, p, CGS1, DR1 & T	1	yes	yes	m3 = -0.112 y**– 0.477 p* - 0.623 CGS1* + 1.195 DR1** + 0.205 T* + e3 (0.052) (0.073) (0.122) (0.534) (0.007)	32.84 [0.00]
M0	Nominal reserve money					
4.	m0, y, p & T	1	no	yes	m0 = 0.422 y – 0.589 p + 0.176 T* + e4 (0.333) (0.374) (0.04)	8.180 [0.00]
5.	m0, y, p, CGS1 & T	1	yes	yes	m0 = - 0.118 y – 1.260 p** - 0.187 CGS1 + 0.256 T* + e5 (0.470) (0.60) (0.579) (0.067)	10.01 [0.00]
6.	m0, y, p, CGS1, DR1 & T	1	yes	yes	m0 = 0.213 y – 1.310 p* - 0.949 CGS1** + 5.710 DR1* + 0.236 T* + e6 (0.180) (0.073) (0.362) (1.58) (0.024)	30.89 [0.00]
M1	Nominal narrow money					
7.	m1, y, p & T	1	no	yes	m1 = 2.389 y* + 0.899 p *- 0.053 T* + e7 (0.242) (0.222) (0.024)	4.86 [0.028]
8.	m1, y, p, DR1 & T	1	yes	yes	m1 = 2.31 y * + 0.670 p* + 3.660 DR1* - 0.038 T +e8 (0.212) (0.222) (1.715) (0.021)	3.20 [0.070]
9.	m1, y, p, DR1, CGS1 & T	1	yes	yes	m1 = 2.189 y* + 0.180 p + 6.708 DR1* - 0.971 CGS1*** + 0.004 T+e9 (0.198) (0.308) (2.160) (0.485) (0.027)	0.024 [0.878]

Notes: Error of the long-term relationship is represented with ‘ei’, where i = 1 to 9, the number of equation in Table. Asymptotic standard errors are provided in the parenthesis (). *significant at 1% level, **significant at 5% level and ***significant at 10% level.

6.4.4 ECM for Narrow Money Demand in two Steps

The long run relationship from the above analysis can be used to design an error correction model in the tradition of two-step ECM. The dynamics of the system is obtained from the error term calculated using the long-term relationship of the cointegrating vector.

Considering that the trend is insignificant in long-term relationships presented at line 8 and 9 in Table 6.6, the coefficients for other variables are re-estimated with the restriction that trend is zero. The design and test results for these vectors are presented in Annexure 6.4. The revised long-term relationships for narrow money are summarized in Table 6.7 with ERDM1A, ERDM1B and ERDM1C as the error correction terms. The deviation of narrow money stock from its long-term equilibrium values is a function of error correction term.

Table 6.7 Selected long run equations for estimating alternative ECM for demand for nominal narrow money M1 (1971-98)

$$m1 = \underset{(0.242)}{2.389}\, y^* + \underset{(0.222)}{0.899}\, p^* - \underset{(0.024)}{0.053}\, T^{**} + ERDM1A$$

$$m1 = \underset{(0.176)}{2.098}\, y^* + \underset{(0.123)}{0.301}\, p^* + \underset{(1.172)}{4.447}\, DR1^* + ERDM1B$$

$$m1 = \underset{(0.158)}{2.208}\, y^* + \underset{(0.111)}{0.224}\, p^* + \underset{(1.827)}{6.534}\, DR1^* - \underset{(0.407)}{0.931}\, CGS1^* + ERDM1C$$

Note: See Annexure 6.4 of this chapter for the structural design of cointegrating vectors. Standard errors are in parenthesis ().

Using lagged errors from long-term relationships in Table 6.7, along with lagged and contemporaneous difference terms of all the variables in the cointegrating vector and other variables that are expected to affect the money demand, the ECM specifications are presented in Table 6.8. Models DM1A, DM1B and DM1C include only the error terms, while DM1A1 and DM1B1 also include the first difference of interest rates. Differenced variables that are not significant are not retained in models DM1A1 and DM1B1 following the principle of general to specific model.

Clearly, the errors ERDM1B and ERDM1C alone have no explanatory power, while ERDM1A errors have significant explanatory power. This means that the long-run effects of interest rates are not as useful as some form of technological variable captured by the trend term.

Table 6.8 ECM for demand for nominal narrow money (1971-98)

Dependent Variable	Δml	Δml	Δml	Δml	Δml
Model number	DM1A	DM1B	DM1C	DM1A1	DM1B1
INTERCEPT	-8.387***	-5.900	-3.360	-7.990**	-8.480*
	(4.220)	(3.620)	(3.810)	(3.524)	(2.840)
ERDM1A (-1)	-0.317**			-0.302**	
	(0.157)			(0.131)	
ERDM1B (-1)		-0.284			-0.405*
		(0.170)			(0.134)
ERDM1C (-1)			-0.153		
			(0.167)		
ΔDR1				4.150*	4.940*
				(1.180)	(1.135)
ΔCGS1				-1.360**	-1.520**
				(0.645)	(0.607)
R-Square	0.14	0.097	0.03	0.44	0.51
R-Bar-Square	0.10	0.062	-0.01	0.38	0.45
S.E of Regression	0.06	0.06	0.064	0.05	0.047
Diagnostic Tests					
DW-statistics	2.01	2.2	2.34	2.01	2.07
LM (3) serial correlation	0.08 [0.90]	0.74 [0.86]	1.36 [0.72]	2.38 [0.50]	1.80 [0.62]
ARCH (3) test	0.53 [0.91]	0.47 [0.93]	0.40 [0.94]	1.65 [0.65]	1.82 [0.61]
Functional Form CHSQ (1)	0.17 [0.68]	0.40 [0.53]	0.36 [0.55]	5.13 [0.02]	6.22 [0.01]
Normality CHSQ (2)	29.6 [0.00]	44.3 [0.00]	48.5 [0.00]	3.57 [0.17]	1.18 [0.55]
Predictive failure CHSQ (6)				5.59 [0.47]	7.77 [0.19]
Stability test CHSQ (4)				4.23 [0.37]	6.50 [0.17]
Residual Unit root test					
Test statistics (DF)	-5.04	-3.58	-5.89	-5.09	-5.35

Notes: Predictive failure test and parameter stability tests are conducted by breaking the sample at 1992. Unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

However, with inclusion of changes in the interest rate variable the error term ERDM1B is also significant but the functional form of the short run dynamics is not satisfactory. Full model corresponding to error ERDM1C is not presented as it is not as satisfactory as the other two. Other statistical properties of both error correction models, DM1A1 and DM1B1 are satisfactory but model DM1B1 is found to encompass model DM1A1. The CUSUM and CUSUM of squares tests did not show any sign of structural break. The predictive failure and stability test of coefficients are also satisfactory. It may be noted that the coefficients of the error terms are not big enough to suggest quicker adjustments from the long-term relationship. Most of the explanatory powers of the models are drawn from the high coefficients of the changes in interest rates. As in the case of broad and narrow money, output does not appear to play an important role for short-run narrow money demand. However, as demonstrated in Chapter 5, narrow money growth is important in determining the level of inflation. In this context, interest rates can be important variables in order to control narrow money in the short-run.

6.5 POLICY IMPLICATIONS AND CONCLUSION

Three common monetary aggregates have been analyzed in this chapter from the perspective of their relevance in conducting monetary policy. An attempt has been made to model and test the robustness of the long run relationship between output and broad money stock in a variety of long-term specifications of demand for real broad money using data for the period 1970-98, which includes the post reform period. The outcome is disappointing. When broad money is specified as a standard demand equation, output, a key variable is not at all robust to the inclusion of other relevant variables like, inflation, interest rate, and trend. The examination of the base money demand also meets the same outcome.

Therefore, it is concluded that the money-output relationship in India is very loose and any attempt to conduct monetary policy based on the paradigm of a stable demand for money is likely to be more a failure than a success. As discussed earlier, the loosening of the relationship between money and output may be due to the operation of Goodhart's law. Discretionary supply of money due to various reasons such as fiscal deficit, directed credit, and interventions in foreign exchange market, must have helped in loosening the money-output relationship.

There is evidence to suggest the demand for narrow money is better defined but it may not really assist, because narrow money by definition neither represents base money over which the central bank has better control nor all the institutional categories of money. Therefore, conducting monetary policy based on narrow money could at best be a temporary arrangement until the interest rate becomes the major instrument of monetary policy.

In most studies on monetary aggregates in India, it has been assumed there is no public money illusion. However, simple regression analyses reveal this assumption is not robust. Demand for money does not imply demand for real money. The price level should be treated as a separate variable when modeling nominal or real money.

Annexure 6.1 Summary definition of data used in Chapter 6

Symbol	Variable description and unit of measurement
BDR	Bankers' Deposits with RBI (rupees million).
CC	Currency in Circulation (rupees million).
CGS1	Bond rate: Annual yield on 1-5 Year government of India (GOI) Securities, taken in fraction. Middle point has been taken for the data given in range.
CIB	Cash on Hand with Banks (rupees million).
CMR	Overnight annual call money rate of commercial banks taken in fraction
CRR	Cash Reserve Ratio: derived according to the RBI notifications as fraction of time plus demand deposits. Average of the notified values during the year
CUP	Currency with the Public (rupees million).
DD	Demand Deposits with Banks (rupees million).
DR1	1-3 Year commercial banks annual deposit rates taken in fraction.
GDP	GDP at market prices at current prices (rupees million)
M0	Base (Reserve) Money (rupees million). M0 = CUP+CIB + BDR + ODR
M0R	Real base money = M0/P
M1	Narrow Money (rupees million). M1 = CUP+ODR+DD
M1R	Real narrow money = M1/P
M3	Broad Money (rupees million). M3 = CUP + DD + TD + ODR
M3R	Real broad money = M3/P
ODR	Other Deposits with RBI (rupees million)
P	Wholesale price index (WPI) of all commodities converted to base 1993-94 = 100
SLR	Statutory Liquidity Ratio according to the RBI notifications taken as fraction of time and demand deposits. Average of the notified values during the year.
TD	Time Deposits with Banks (rupees million).
Y	Gross domestic product at constant market prices (rupees millions)
YP	Permanent real income calculated according to the error-learning hypothesis discussed in Ladler (1989:88) with geometric wt for last 10 years and weight of 0.5 for current year's real GDP at factor cost.

Annexure 6.2: Unit root test for the variables used in Chapter 6 in levels and first differences

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
CGS1	DF	-2.980	-1.23	69.22	67.96	-3.594	-1.48	68.69	66.81
	ADF (1)		-1.41	68.94	67.05		-2.00	69.09	66.58
	ADF (2)		-1.15	68.60	66.09		-1.48	68.25	65.10
ΔCGS1	DF	-2.985	-3.98	65.66	64.45	-3.603	-3.92	64.75	62.92
	ADF (1)		-3.95	65.61	63.78		-3.91	64.77	62.33
CRR	DF	-2.980	-1.68	77.54	76.29	-3.594	-0.74	76.54	74.66
	ADF (1)		-1.68	77.03	75.14		-1.37	76.44	73.93
ΔCRR	DF	-2.985	-4.41	76.10	74.88	-3.603	-4.26	75.23	73.40
	ADF (1)		-3.74	75.37	73.54		-3.66	74.57	72.13
CMR	DF	-2.980	-3.67	52.64	51.38	-3.594	-3.52	51.75	49.86
	ADF (1)		-3.84	52.52	50.63		-3.84	52.13	49.62
DR1	DF	-2.980	-1.71	85.73	84.48	-3.594	-2.99	87.77	85.89
	ADF (1)		-1.75	84.88	82.99		-4.74	91.64	89.12
	ADF (2)		-1.16	87.12	84.60		-3.18	90.67	87.53
ΔDR1	DF	-2.985	-4.55	80.47	79.25	-3.603	-4.55	79.78	77.95
	ADF (1)		-5.72	83.52	81.70		-5.70	82.91	80.47
	ADF (2)		-4.71	83.93	81.49		-4.61	83.22	80.18
$m0$	DF	-2.980	-0.17	33.69	32.44	-3.594	-2.95	36.86	34.97
	ADF (1)		-0.15	32.71	30.82		-3.41	37.20	34.68
$\Delta m0$	DF	-2.985	-4.93	32.06	30.84	-3.603	-4.83	31.08	29.25
	ADF (1)		-4.17	31.64	29.81		-4.09	30.68	28.24
$m1$	DF	-2.980	1.07	33.00	31.74	-3.59	-2.19	34.70	32.81
	ADF (1)		1.49	33.54	31.65		-1.77	34.56	32.05
	ADF (2)		1.75	33.11	30.59		-1.55	33.85	30.70
$\Delta m1$	DF	-2.985	-6.30	31.52	30.30	-3.603	-6.91	32.39	30.56
	ADF (1)		-4.03	30.59	28.76		-4.88	32.14	29.70
$m3$	DF	-2.980	0.23	58.45	57.19	-3.594	-3.20	62.26	60.38
	ADF (1)		0.23	57.51	55.62		-3.70	62.82	60.30
$\Delta m3$	DF	-2.985	-5.08	55.66	54.44	-3.603	-4.98	54.71	52.88
	ADF (1)		-4.10	55.09	53.26		-4.02	54.14	51.70
$m0r$	DF	-2.980	0.02	25.53	24.27	-3.594	-3.34	29.79	27.91
	ADF (1)		-0.09	24.77	22.89		-4.23	31.58	29.07
	ADF (2)		0.02	24.01	21.50		-4.43	31.71	28.57
$\Delta m0r$	DF	-2.985	-4.29	24.42	23.20	-3.603	-4.20	23.44	21.62
	ADF (1)		-3.62	23.66	21.83		-3.55	22.70	20.26
$m1r$	DF	-2.980	0.82	26.34	25.08	-3.594	-3.46	31.65	29.77
	ADF (1)		1.30	26.61	24.72		-3.04	31.39	28.87
	ADF (2)		1.82	26.96	24.45		-2.78	31.73	28.58
$\Delta m1r$	DF	-2.985	-6.20	25.73	24.51	-3.603	-6.65	26.26	24.44
	ADF (1)		-4.49	25.14	23.31		-5.40	26.93	24.50
$m3r$	DF	-2.980	0.45	32.35	31.09	-3.594	-3.21	36.35	34.47
	ADF (1)		0.24	32.14	30.25		-5.19	41.69	39.17
	ADF (2)		0.42	32.40	29.88		-5.16	42.23	39.08

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend. 95% critical value	Statistic	AIC	SBC	The Dickey-Fuller regressions include an intercept and a linear trend 95% critical value	Statistic	AIC	SBC
$\Delta m3r$	DF	-2.985	-3.91	32.63	31.41	-3.603	-3.80	31.63	29.80
	ADF (1)		-4.06	32.80	30.97		-3.96	31.82	29.38
	ADF (2)		-3.79	32.43	29.99		-3.70	31.48	28.43
MM1	DF	-2.980	-2.02	28.48	27.22	-3.594	-1.39	27.49	25.60
	ADF (1)		-2.12	28.05	26.16		-1.75	27.27	24.76
ΔMM1	DF	-2.985	-4.05	25.44	24.23	-3.603	-4.17	25.01	23.18
	ADF (1)		-4.07	25.53	23.70		-4.34	25.52	23.08
	ADF (2)		-2.81	24.55	22.11		-3.11	24.52	21.47
MM3	DF	-2.980	-0.73	11.92	10.66	-3.594	-2.26	13.35	11.46
	ADF (1)		-0.64	10.93	9.05		-2.40	12.83	10.31
	DF	-2.985	-5.10	10.99	9.77	-3.603	-5.00	10.01	8.18
ΔMM3	ADF (1)		-3.84	10.19	8.36		-3.76	9.21	6.77
	ADF (2)		-3.70	10.36	7.93		-3.59	9.39	6.34
p	DF	-2.980	-1.05	38.18	36.92	-3.594	-3.20	41.70	39.82
	ADF (1)		-0.92	37.90	36.01		-4.93	46.33	43.82
	ADF (2)		-0.93	38.80	36.28		-4.28	45.75	42.61
Δp	DF	-2.985	-4.10	38.41	37.19	-3.603	-3.97	37.41	35.58
	ADF (1)		-4.43	39.00	37.17		-4.29	38.01	35.57
	ADF (2)		-3.57	38.16	35.73		-3.47	37.18	34.14
$reer$	DF	-2.980	0.09	29.29	28.03	-3.594	-1.90	30.44	28.56
	ADF (1)		0.00	28.40	26.52		-2.02	29.85	27.34
$\Delta reer$	DF	-2.985	-4.44	28.14	26.92	-3.603	-4.37	27.21	25.39
	ADF (1)		-2.91	27.27	25.44		-2.84	26.31	23.87
y	DF	-2.980	1.24	53.29	52.04	-3.594	-2.13	54.93	53.05
	ADF (1)		1.58	52.98	51.09		-1.85	54.22	51.71
Δy	DF	-2.985	-5.70	50.48	49.26	-3.603	-6.10	50.85	49.02
	ADF (1)		-3.83	49.48	47.65		-4.35	50.18	47.74
yp	DF	-2.980	3.31	71.96	70.70	-3.594	-1.03	71.99	70.11
	ADF (1)		2.34	71.01	69.12		-1.04	71.06	68.54
Δyp	DF	-2.985	-3.46	66.12	64.90	-3.600	-4.52	68.09	66.26
	ADF (1)		-2.69	65.22	63.40		-3.92	67.61	65.17
V0	DF	-2.980	-1.21	-31.60	-32.85	-3.594	-2.58	-30.06	-31.95
	ADF (1)		-1.30	-32.38	-34.27		-3.29	-29.12	-31.63
	ADF (2)		-1.10	-33.17	-35.69		-3.34	-29.31	-32.46
ΔV0	DF	-2.985	-4.50	-31.53	-32.75	-3.603	-4.41	-32.52	-34.34
	ADF (1)		-3.85	-32.12	-33.95		-3.77	-33.10	-35.54
V1	DF	-2.980	-2.29	-21.19	-22.45	-3.594	-4.34	-16.55	-18.43
	ADF (1)		-1.59	-21.72	-23.61		-3.52	-17.46	-19.97
ΔV1	DF	-2.985	-6.86	-21.63	-22.84	-3.603	-6.96	-22.00	-23.83
	ADF (1)		-5.91	-20.38	-22.20		-6.37	-19.81	-22.25
	ADF (2)		-4.00	-21.24	-23.67		-4.66	-20.11	-23.16
V3	DF	-2.980	-0.88	1.25	0.00	-3.594	-1.90	1.75	-0.13
	ADF (1)		-0.94	0.83	-1.06		-2.72	3.11	0.59
	ADF (2)		-0.92	2.89	0.38		-1.58	3.01	-0.14

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
ΔV3	DF	-2.985	-3.85	1.96	0.74	-3.603	-3.82	1.18	-0.65
	ADF (1)		-4.71	3.66	1.83		-4.79	3.21	0.77
	ADF (2)		-3.28	2.66	0.22		-3.41	2.24	-0.81

Note: ADF = Augmented Dickey Fuller. AIC = Akaike Information Criterion. SBC = Schwarz Bayesian Criterion of model selection. The order of ADF test is chosen as 2 in all the cases. Numbers of observations vary from 23 to 26.

Annexure 6.3 Test results for cointegration between variables in alternative specifications of demand for money function (reference Table 6.6) (1971-98)

Maximum Eigenvalue Test					Trace Test					No. Of vectors Selected
Hypothesis		Statistic	Critical values		Hypothesis		Statistic	Critical values		
Null	Alternative		95%	90%	Null	Alternative		95%	90%	
Variable set: m3, y, p, Trend.										
Eigenvalues: 0.52343, 0.43047, 0.26976, 0										
r = 0	r = 1	20.75	25.42	23.10	r = 0	r = 1	45.32	42.34	39.34	1
r<= 1	r = 2	15.76	19.22	17.18	r<= 1	r<= 2	24.57	25.77	23.08	
r<= 2	r = 3	8.80	12.39	10.55	r<= 2	r<= 3	8.80	12.39	10.55	
Variable set: m3, y, p, CGS1, Trend										
Eigenvalues: 0.72574, 0.44794, 0.31128, 0.1157, 0										
r = 0	r = 1	36.22	31.79	29.13	r = 0	r = 1	66.74	63.00	59.16	1
r<= 1	r = 2	16.63	25.42	23.10	r<= 1	r<= 2	30.52	42.34	39.34	
r<= 2	r = 3	10.44	19.22	17.18	r<= 2	r<= 3	13.88	25.77	23.08	
r<= 3	r = 4	3.44	12.39	10.55	r<= 3	r<= 4	3.44	12.39	10.55	
Variable set: m3, y, p, CGS1R, DR1R										
Eigenvalues: 0.82736, 0.49966, 0.44219, 0.29579, 0.11603, 0										
r = 0	r = 1	49.18	37.86	35.04	r = 0	r = 1	98.19	87.17	82.88	1
r<= 1	r = 2	19.39	31.79	29.13	r<= 1	r<= 2	49.01	63.00	59.16	
r<= 2	r = 3	16.34	25.42	23.10	r<= 2	r<= 3	29.62	42.34	39.34	
r<= 3	r = 4	9.82	19.22	17.18	r<= 3	r<= 4	13.27	25.77	23.08	
Variable set: m0, y, p, Trend										
Eigenvalues: 0.58181, 0.4308, 0.34924, 0										
r = 0	r = 1	24.41	25.42	23.10	r = 0	r = 1	52.22	42.34	39.34	1
r<= 1	r = 2	15.78	19.22	17.18	r<= 1	r<= 2	27.81	25.77	23.08	
r<= 2	r = 3	12.03	12.39	10.55	r<= 2	r<= 3	12.03	12.39	10.55	
Variable set m0, y, p, CGS1R, Trend										
Eigenvalues: 0.64698, 0.49492, 0.3834, 0.12111, 0										
r = 0	r = 1	29.15	31.79	29.13	r = 0	r = 1	65.43	63.00	59.16	1
r<= 1	r = 2	19.13	25.42	23.10	r<= 1	r<= 2	36.28	42.34	39.34	
r<= 2	r = 3	13.54	19.22	17.18	r<= 2	r<= 3	17.15	25.77	23.08	
r<= 3	r = 4	3.61	12.39	10.55	r<= 3	r<= 4	3.61	12.39	10.55	
Variable set: m0, y, p, CGS1R, DR1R										
Eigenvalues: 0.8653, 0.56007, 0.41435, 0.34191, 0.11499, 0										
r = 0	r = 1	56.13	37.86	35.04	r = 0	r = 1	109.24	87.17	82.88	1
r<= 1	r = 2	22.99	31.79	29.13	r<= 1	r<= 2	53.11	63.00	59.16	
r<= 2	r = 3	14.98	25.42	23.10	r<= 2	r<= 3	30.12	42.34	39.34	
r<= 3	r = 4	11.72	19.22	17.18	r<= 3	r<= 4	15.14	25.77	23.08	
Variable set: m1, y, p, Trend										
Eigenvalues: 0.70125, 0.4284, 0.19029, 0										
r = 0	r = 1	33.83	25.42		r = 0	r = 1	55.40	42.34	39.34	1
r<= 1	r = 2	15.66	19.22		r<= 1	r<= 2	21.57	25.77	23.08	
r<= 2	r = 3	5.91	12.39		r<= 2	r<= 3	5.91	12.39	10.55	
Variable set: m1, y, p, DR1, Trend										
Eigenvalues: 0.70125, 0.4284, 0.19029, 0										
r = 0	r = 1	37.84	31.79	29.13	r = 0	r = 1	75.04	63.00	59.16	1
r<= 1	r = 2	17.15	25.42	23.10	r<= 1	r<= 2	37.20	42.34	39.34	
r<= 2	r = 3	12.07	19.22	17.18	r<= 2	r<= 3	20.05	25.77	23.08	
r<= 3	r = 4	7.99	12.39	10.55	r<= 3	r<= 4	7.99	12.39	10.55	
Variable set: m1, y, p, DR1, CGS1, Trend										
Eigenvalues: 0.78094,0.5698, 0.41786, 0.3236, 0.14061, 0										
r = 0	r = 1	42.51	37.86	35.04	r = 0	r = 1	96.48	87.17	82.88	1
r<= 1	r = 2	23.62	31.79	29.13	r<= 1	r<= 2	53.96	63.00	59.16	
r<= 2	r = 3	15.15	25.42	23.10	r<= 2	r<= 3	30.34	42.34	39.34	
r<= 3	r = 4	10.95	19.22	17.18	r<= 3	r<= 4	15.19	25.77	23.08	

Note: The number of cointegrating vectors is represented with r. All tests are done applying likelihood ratio test on the maximum eigenvalue and trace of the stochastic matrix in VECM specification with restricted trend and unrestricted intercept. Period: 1971- 98, Order of VAR = 1.

Annexure 6.4 Structure of the cointegrating vectors for modeling demand for narrow money (reference Tables 6.6 & 6.7) (1971-98)

Model – DM1A: List of variables included in the cointegrating vector: m1, y, p, Trend
Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.
Imposed Restriction: a1=1

	m1	y	p	Trend
Vector: a	1.000	-2.389*	-0.899*	0.053**
Std. Error	(NONE)	(0.242)	(0.222)	(0.0238)

LL subject to exactly identified restrictions = 159.196. LR test of additional restriction (a4=0): CHSQ (1) = 4.856[.028], LL subject to over identified restrictions = 156.768

Model –DM1B: List of variables included in the cointegrating vector: m1, y, p, DR1, Trend
Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.
Imposed Restriction: a1=1

	m1	y	p	DR1	Trend
Vector: a	1.000	-2.3096	-0.66984	-3.6592	0.038262
Std. Error	(NONE)	(0.212)	(0.222)	(1.715)	(0.021)
Imposed Restriction: a1=1; a5=0					
Vector: a	1.000	-2.0979*	-0.3006*	-4.4468*	0.000
Std. Error	(NONE)	(0.176)	(0.123)	(1.818)	(NONE)

LL subject to exactly identified restrictions = 259.99. LR test of additional restriction (a5=0): CHSQ (1) = 3.1997[.074], LL subject to over identified restrictions = 258.393

Model – DM1C: List of variables included in the cointegrating vector: m1, y, p, DR1, CGS1Trend.
Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.
Imposed Restriction: a1=1

	m1	y	p	DR1	CGS1	Trend
Vector: a	1.000	-2.1894	-0.1799	-6.7080	0.97124	-0.0042
Std. Error	(NONE)	(0.19839)	(0.30755)	(2.1557)	(0.48486)	(0.0274)
Imposed Restriction: a1=1; a6=0						
Vector: a	1.000	-2.2076	-0.22391	-6.5341	0.93129	0.00
Std. Error	(NONE)	(0.158)	(0.1106)	(1.8269)	(0.4075)	(NONE)

LL subject to exactly identified restrictions = 343.28. LR test of additional restriction (a6=0): CHSQ (1) = 0.0236[.878], LL subject to over identified restrictions = 343.273

Notes: Values in parenthesis () are standard errors. *significant at 1% level, **significant at 5% level and ***significant at 10% level.

Chapter 7

Money Supply Behaviour

7.1 INTRODUCTION

The analysis in the previous chapter indicates that the functions of demand for broad and base money are not well defined in the case of the Indian economy for the data set analyzed, which includes the most recent periods. Therefore, the identity that the money supply equals money demanded is not well defined in the case of India making it important to analyze the endogenous behavioural pattern of the money supply. In addition, as discussed in Chapter 5 inflation at least over the medium term is not entirely a monetary phenomenon in India. However, as Chapter 5 identified narrow money M1 as the appropriate monetary aggregate for accounting monetary effects on inflation, it is particularly important to estimate a behavioural model for determining the stock of M1 in the economy, so that the important variables that can explain M1 supply can be identified as valid control instruments. The behavioural model for determining the stock of the broad money M3 is also examined in this chapter, as M3 is the monetary aggregate that is being used as an intermediate target of monetary policy in India at present. This analysis facilitates a comparison between the behavioural models of M1 and M3 supply.

Specifically, the basic question is what determines money supply behaviour? This calls for modeling the broader monetary aggregates so that their supply can be related to the supply of base money, which can be better controlled by the RBI. As discussed above, since broader aggregates include institutional money, variables likely to determine the cash holding behaviour of people and banks become important in determining the total stock of money. In this context, theories of the supply of money dealing with inside and outside money, or more relevantly money produced by the government and central bank and money produced by intermediation, become relevant to estimation and discussion.

The traditional literature on the supply of broader aggregates of money is concerned with the banking money multiplier analysis, which is basically a money determinants analysis with a blend of money demand and supply modeled in terms of the preferences of the final agents who hold money stock, such as the public, banks and government. [73] Such preferences determine the proximate determinants of money stock known as currency and cash reserves to deposits ratios and stock of high power money (also known as base or reserve money). This assumes base money is exogenously determined, which does not seem to be true in the case of India, as indicated by the causality test in Chapter 5 and the discussion in the previous chapter. As broad money demand is not well defined, it is difficult to credit that base money supply is a response to the maintained desired rate of growth in broad money. The RBI may respond to the fiscal deficit and the borrowing potential of government by partly monetizing the deficit and thus, increase the monetary base.[74] Finally, the central bank can resort to open market operations in response to the interest rate and exchange rate movements. This may leave base money itself as an endogenous variable.

Therefore, an attempt is made in this chapter to examine the effects of institutional and macroeconomic variables on the money generating process by estimating functions for the multipliers and base money supply. The fiscal deficit is used to identify the long run supply functions for base money. Other variables that are assumed to affect the base money supply behaviour of the RBI are identified as the real exchange rate, the interest rate, output, price level, foreign exchange reserves and inflation.

The rest of this chapter is organized as follows: Section 7.2 develops a simple analytical framework for multiplier equation and estimates and discusses the narrow and broad money multipliers. Nominal base money supply is modeled and discussed in section 7.3, where the effect of fiscal deficit on economic growth is also analyzed with reference to the discussion in Chapters 4 and 5. Section 7.4 concludes. Data

[73] In a related context using monthly data for period 1980-2000, Jha and Rath (2001) have argued that money multiplier in India is endogenous.

[74] The greater the amount of deficit finance, the greater will be the demand for credit and the higher the interest rates. High rates of interest could reduce the demand for investment in the private sector (Ghatak 1981). In order to maintain the interest rate and private sector investment, the central bank may find it preferable to monetize part of the deficit.

description is provided in Annexure 7.1 of this chapter and Appendix AA of this thesis.

7.2 MONEY MULTIPLIERS

In the simplest form, the money multiplier for a particular monetary aggregate is defined as the ratio of the stock of that aggregate to the stock of high power or base money. As discussed earlier in this study, narrow money M1 and broad money M3 are considered for analysis. The high power money or the base money (M0) is alternatively represented with H. As explained in detail in Chapter 6, in the case of India these aggregates are defined as follows.

M0=CUP+CIB+BDR+ODR
M1=CUP+ODR+DD
M3=M1+TD
CUP = Currency with public
CIB = Cash in banks
BDR = Banker's deposit with RBI
ODR = Other deposits with RBI
DD = Demand deposits in banks
TD = Time deposits in banks

As discussed in Chapter 6 (see Table 6.1) narrow money (M1) in India has three components: currency with the public (CUP), demand deposits (DD) with commercial banks and other deposits (ODR) with the RBI. CUP and DD together constitute almost 99 percent of M1. The broad money is the sum of narrow money and time deposit. In view of the fact that, the ODR component is about one percent of narrow money and a still smaller component of broad money, it is assumed to be insignificant for further discussion.

Together, CIB and BDR can be considered as the total reserve (R) in the banking sector, which can be divided in to two components, required cash reserve (RR), defined by the statutory cash reserve ratio (CRR) and excess reserve (ER) in the banking sector, defined by the variability of deposit flows and short term money market conditions. Thus CIB + BDR = R = RR+ER. Thus, high power money can be defined as: H = M0 = R + CUP. Representing total deposits with D = DD + TD, high power money, narrow money and broad money can be represented in terms of the following ratios. The currency to deposit ratio $c = CUP / D$, reserves to deposit ratio $r = R / D$, and demand deposit to total deposit ratio $d = DD / D$. Thus,

$$H = R + CUP = (r + c)D \tag{7.1}$$

$$M1 = CUP + DD = (c + d)D \tag{7.2}$$

$$M3 = CUP + DD + TD = (1 + c)D \tag{7.3}$$

From equations (7.1) to (7.3), the two multipliers for broad money (MM3) and narrow money multiplier (MM1) can be written in terms of their proximate determinants as follows:

$$MM1 = \frac{M1}{H} = \frac{(d + c)}{(r + c)} \tag{7.4}$$

$$MM3 = \frac{M3}{H} = \frac{(1 + c)}{(r + c)} \tag{7.5}$$

Both multipliers increase with decreasing 'r'. Given the fact that 'r' is less than one, the broad money multiplier increases with decreasing 'c'. From the data provided in Table 6.1, Chapter 6, it can be inferred that on average 'd' is more than 'r' (see CLR in Table 6.1, which is the same as 'r'). Therefore, the narrow money multiplier is also more likely to increase with decreasing 'c'. However, it is important to remember that 'd' is not a constant and can vary with time depending upon other macroeconomic variables as it can be regarded as representing the share of the transaction deposit in total deposits. Realizing that the ratios 'r', 'c', and 'd' can change with time, in view of the fact that the behavioural pattern of the public, commercial banks, the RBI and the government changes with changing macroeconomic variables like deposit rates, bond rates, variability of deposits, institutional developments and the regulatory framework, the above ratios can be expressed as functions of such macroeconomic variables (see for example Dornbusch and Fischer (1994), Brunner and Meltzer (1990), Fisher (1989)). At the outset, it may be noted that in India, the cash reserve ratio (CRR) is one of the main regulatory instruments of monetary policy and is changed several times a year.

Among the potential variables that can affect individual cash holding behaviour, are interest rates on deposits and yields on bonds. Similarly, a variable such as the inter bank call money rates (CMR) can indicate the behaviour of commercial banks in holding cash in addition to that statutorily required by the CRR. A high CMR will indicate that banks hold less cash in reserve and therefore a lower 'r'.

In addition to price variables like interest rates, institutional development in a country can also determine individual cash holding behaviour. Commercial bank density (CBDN), measured in terms of thousands of population per branch, can proxy such a variable of institutional development in the case of a developing country like India. During the 1970s, CBDN dropped drastically from 48 thousand people per branch to 21 following bank nationalization in 1969 and the massive program under taken by banks to reach the people. However, this drop has slowed during the later decade, reaching 15 thousand people per branch during 1998-99.

The effect of the increase in the number of commercial bank branches can be seen directly on the changes in the composition of the monetary aggregates presented in Table 6.1, Chapter 6. While the CUP component of narrow money (M1) has been declining, the DD component of M1 has been increasing. It may be pointed out that the correlation coefficient between CBDN and ratio M3 to M1 and ratio M1 to M0 are 0.97 and 0.89, respectively. The ratio of DD to CUP has risen from 67 to 81 percent. This demonstrates that people's preference for keeping cash has reduced with an increasing number of banks branches. In other words, when banks are not at far off distances people prefer to keep smaller quantities of cash. Another way in which CBDN affects the M1 component is through the switching of demand deposits to high interest bearing time deposits. With more banks (low CBDN) people are more educated and motivated to keep money in time deposits and earn some interest.[75]

Thus, it is expected that with lowering CBDN, growth in M1 should also be lower. In other words, M1 growth and CBDN are expected to have a positive relationship. Since the effect of CBDN is drawn from the substitution of the component of narrow money with the time deposit component of M3. With more banks, people deposit their money wealth in time deposits, which reduces M1. This

[75] However, as pointed out in the previous chapter, despite large increases in the number of bank branches, the currency holding per person (CUPPP) in nominal terms as well as in real terms (CUPPPR) has increased several fold during the sample period. This simply means that institutional development in terms of opening up of new branches of banks is not keeping pace with rising incomes.

means CBDN will have the opposite effect on the broad money multiplier. Thus the above ratios can be written in the following form:

$$r = f(\underset{+}{CRR}, \underset{-}{CMR}, ...) \tag{7.6}$$

$$c = f(\underset{-}{Deposit\ Rates}, \underset{-}{Yield\ on\ Bonds}, \underset{-}{CBDN}, ...) \tag{7.7}$$

$$d = f(\underset{-}{Deposit\ Rates}, \underset{-}{Yield\ on\ Bonds}, \underset{+}{CBDN}, ...) \tag{7.8}$$

Substituting equations (7.6) to (7.8) in equations (7.4) and (7.5) the reduced form equation for multipliers in terms of the behavioural variables can be written as follows:

$$MM1 = f(\underset{-}{CRR}, \underset{+}{CMR}, Deposit\ Rates, Yield\ on\ Bonds, \underset{+}{CBDN}) \tag{7.9}$$

$$MM3 = f(\underset{-}{CRR}, \underset{+}{CMR}, \underset{+}{Deposit\ Rates}, \underset{+}{Yield\ on\ Bonds}, \underset{-}{CBDN}) \tag{7.10}$$

The expected sign of the partial derivatives are presented below the variables. It may be noted that the overall effect of deposit rates and the yield on bonds on the narrow money multiplier is not clear due to the opposite affects of 'c' and 'd' on MM1. In the case of MM3, such ambiguity is not present.

As discussed in the earlier chapters, interest rate variables, namely the average interest rate on 1-3 year deposits (DR1), the average yield on 1-5 years government securities (CGS1), and the average overnight inter bank call money rate (CMR) are chosen for this experiment, because the series on these data are reliably and easily available. A summary on data description is presented in Annexure 7.1. More details on data like sources and constructed data are provided in Appendix AA of the thesis.

In modeling multipliers, it is important to capture long-run relationships along with the short-run behaviour of the explanatory variables. This calls for modeling in the error correction framework. In estimation, multipliers are taken in logs and therefore, represented with small case letters, mm1 and mm3, while keeping CBDN as thousand persons per branch, and the interest rates (CGS1, DR1, and CMR) and the CRR in fractions. The time series property of the variables is assessed by conducting ADF based unit root tests. The unit root test results presented in Annexure 7.2 show CBDN and CMR are a stationary variable, while mm1, mm3; DR1, CGS1, and CRR are all integrated of order one. Thus, key variables are not integrated of the same order. A cointegration test conducted with the I(1) variables did not support the presence of a cointegrating vector. However, when stationary variables CMR and CBDN were included in the list of variables including I(1) variables, it obtained a cointegrating vector, which shows that the ordinary least square estimation is expected to be consistent and free from the unit root problem.

Therefore, the method of the single equation restricted error correction modeling (RECM) procedure of Hendry (1995), which allows the model to include lagged dependent and independent variables along with the terms of difference, proved to be more flexible. A careful estimation with respect to the diagnostic properties of the residuals will guard against any spurious content. For this purpose the following unrestricted error correction form is used as followed in Chapter 4.

$$\Delta Y_t = \alpha + \sum_{i=1}^{m-1} A_i^* \Delta Y_{t-i} + \sum_{i=0}^{m-1} B_i^* \Delta X_{t-i} + C_0 Y_{t-m} + C_1 X_{t-m} + \mu_t \tag{7.11}$$

where $C_0 = -\left(I - \sum_{i=1}^{m} A_i\right)$, $C_1 = \left(\sum_{i=0}^{m} B_i\right)$ and $C_0^{-1}C_1$ represents the long-run multiplier for the system. Here α is a vector of constants, Y_t is $(n x 1)$ vector of endogenous variable, X_t is $(k x 1)$ vector of explanatory variables as, A_i and B_i are $(n x n)$ and $(n x k)$ matrices of coefficients, and μ_t is a stochastic error term. A preliminary experimentation with the data indicated that a lag of order one should be enough, which is reasonable for annual data. With equation (7.11) as the general specification the model is 'tested down' by the ordinary least square regression. The insignificant terms, unhelpful in explaining the multipliers are dropped systematically until a statistically acceptable model in a priory theoretical framework is obtained.

7.2.1 Narrow Money Multiplier (MM1)

The estimated dynamic function for a narrow money multiplier is presented in Table 7.1. The long run semi elasticity of a narrow money multiplier with respect to CBDN, CRR, DR1, and CGS1 are also estimated using the variance covariance matrices and the same is presented as the long-run relationships in Table 7.1. The statistical properties of the model are satisfactory and there is no sign of structural break in the estimation when the CUSUM and CUSUM of squares test are performed. The tests of stability of parameters and predictive failure are also satisfactory.

The result in Table 7.1 shows a well-specified model of narrow money multiplier with reasonably high explanatory power. The long-term relationships between the multiplier and the institutional variables are as expected. The narrow money multiplier decreases with cash reserve ratio and increases with an increase in interest rates and bank density. Decrease of narrow money multiplier with expansion of commercial bank branches and fall in CBDN requires explanation. As noted earlier, it may be recalled that the effect of CBDN is drawn from the substitution of the component of narrow money with the time deposit component of M3. With more banks (which means drop in CBDN), people deposit their money wealth in time deposits, which reduces M1. CBDN will have the opposite effect on the broad money multiplier. With increasing returns from bonds (CGS1) and deposits the multiplier increases in the long run as the preferences of banks and people at large for holding cash falls. Similarly with an increase in deposit rates, the effect of a fall in ‘c’ dominates the effect of a fall in ‘d’ both in the long and short run. Therefore, the narrow money multiplier increases.

Table 7.1 Model of narrow money multiplier (1972-99)

Model for MM1: where mml = log (MM1) and Δmml = Δml - Δm0

$$\underset{}{\Delta mml} = \underset{(0.091)}{-0.251^{**}} - \underset{(0.139)}{0.588}\, mml(-1)^{*} + \underset{(0.003)}{0.009}\, CBDN(-1)^{*} - \underset{(0.947)}{2.853}\, CRR(-1)^{*} + \underset{(1.056)}{3.690}\, DR1(-1)^{*}$$

$$+ \underset{(0.605)}{1.396}\, CGS1(-1)^{**} - \underset{(0.726)}{2.568}\, \Delta CRR^{*} + \underset{(1.026)}{4.624}\, \Delta DR1^{*} - \underset{(0.656)}{1.384}\, \Delta CGS1(-1)^{**} + \underset{(0.206)}{0.372}\, \Delta CMR(-1)^{***}$$

R-square = 0.80, R-bar-square = 0.69. SE of regression = 0.032, DW statistics = 1.88. LM serial correlation CHSQ (1) = 0.05[0.83]; LM serial correlation CHSQ (3) = 0.832 [0.84]. ARCH (3) CHSQ (3) = 1.47 [0.69]. Functional form RESET CHSQ (1) = 3.88 [0.05]. Normality CHSQ (2) = 0.36 [0.83]. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 4.62. Predictive failure test (Chow's second test) after breaking the sample at 1992 CHSQ (7) = 7.39 [0.39]. Test of stability (Chow test) of regression coefficients after breaking the sample at 1987 CHSQ (10) = 12.00 [0.29]. *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Long-run Relationship:

$$mml = intercept + \underset{(0.003)}{0.015}\, CBDN^{*} - \underset{(1.780)}{4.850}\, CRR^{*} + \underset{(1.827)}{6.272}\, DR1^{*} + \underset{(1.184)}{2.373}\, CGS1^{***}$$

In the short-run CGS1, has a negative effect on the narrow money multiplier. It may be due to the fact that the immediate effect of a high rate on government bonds results in depletion of the liquidity of banks, which are the main buyers of government securities. The call money rate CMR is significantly positive with a lag in the short run, which can be expected, given the fact that the CMR is an indicator of the liquidity position of commercial banks. A high CMR indicates lower reserves with banks in the short run and therefore an increase in the multiplier with a lag.

The above results clearly show that it is possible to control stocks of narrow money by manipulating interest rate policy. However, it may be mentioned that the most effective control on narrow money can be obtained from control on base money itself. But, as will be discussed in Chapter 8, uncoordinated stances on base money growth and the institutional variables may result in ineffectiveness of the policy. Particularly, the opposing effects of CRR and the base money may cancel out leaving no effect or an undesired effect on narrow money growth.

7.2.2 Broad Money Multiplier (MM3)

Broad money, which is some of narrow money and time deposits, covers more of the institutional category of money. Therefore, the RBI has even lesser control over it and knowledge of the multiplier is important. As pointed out earlier, although the RBI does not work through the multiplier, an attempt is made in this section to demonstrate the effects of institutional parameters on broad money generation by estimating a function for the broad multiplier. The single equation restricted ECM is presented in Table 7.2.

The result in Table 7.2 clearly shows a long-term relationship between the broad money multiplier and the institutional variables of CRR and the deposit rate. The signs of the coefficients of these variables are again in accordance with the theory of the supply of money. An increase in CRR directly reduces the multiplier. An increase in the demand deposit rate would increase term deposits and, reduce public cash holding so that banks would be able to supply more deposits and hence increase the broad money multiplier. Bond rates have short-term effects. An increase in the bond rate leads to substitutions of cash money with bonds as people's preference for holding cash decreases. With a decreasing cash holding ratio of people, the money multiplier increases. As noted earlier, it may be recalled that the effect of CBDN is drawn from the substitution of the component of narrow money with the time deposit component of M3. With more banks, people deposit their money wealth in time deposits, which reduces M1. This means CBDN will have the opposite effect on the broad money multiplier as reflected in the results presented in Table 7.2.

Table 7.2 Model of broad money multiplier (1972-98)

Model for MM3: where mm3 = log (MM3) and Δmm3 = Δm3 - Δm0

$$\Delta mm3 = \underset{(0.006)}{0.352^{*}} - \underset{(0.113)}{0.419}\, mm3\,(-1)^{*} - \underset{(0.356)}{0.689}\, CRR\,(-1)^{***} + \underset{(0.891)}{2.278}\, DR1(-1)^{**} - \underset{(0.585)}{1.878}\, \Delta CRR^{*}$$

$$+ \underset{(0.421)}{0.730}\, \Delta CGS1^{***} + \underset{(0.008)}{0.010}\, \Delta CBDN\,(-1)$$

R-square = 0.63, R-bar-square = 0.51. SE of regression = 0.033, DW statistics = 2.12. LM serial correlation CHSQ (1) = 0.821[0.37]; LM serial correlation CHSQ (2) = 2.061[0.36] LM serial correlation CHSQ (3) = 7.30 [0.07]. ARCH (2) CHSQ (2) = 0.87 [0.65]; ARCH (3) CHSQ (3) = 1.48 [0.69]. Functional form RESET CHSQ (1) = 0.45 [0.50]. Normality CHSQ (2) = 0.88 [0.64]. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 5.28. Predictive failure test (Chow's second test) after breaking the sample at 1990 CHSQ (8) = 11.48 [0.18]. Test of stability (Chow test) of regression coefficients after breaking the sample at 1990 CHSQ (7) = 9.03 [0.25]. *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Long-run Relationship:

$$mm3 = \text{intercept} - \underset{(0.905)}{1.62}\, CRR^{***} + \underset{(1.944)}{5.437}\, DR1^{*}$$

The above relationship can be applied to determine the effects of changes in the base money on the likely change in broad money given other variables. However, as will be discussed in Chapter 8, should the RBI decide to work with more than one instrument, their effectiveness may be compromised. However, in the absence of any stable relationship between output, broad money and price, the relevance of such a relationship is limited. Further, broad money is not found to cause inflation. On the contrary, inflation significantly explains real broad money growth (see Tables 6.5 & 6.6, Chapter 6). Therefore, for inflation targeting, broad money based policy may not be of any significant value.

7.3 NOMINAL BASE MONEY SUPPLY: FISCAL DOMINANCE

It was argued earlier that the base money supply itself could be endogenous in the case of India, particularly in the presence of high fiscal deficits. In his recent address[76] at the fourth Securities Industry summit, Y. V. Reddy (1999d), Deputy Governor of the RBI, commented on the behaviour of base (reserve) money creation observing, 'Consistent with the targeted level of broad money expansion, is a desired level of reserve money expansion. The order of the reserve money expansion, however, has to be consistent with the likely fiscal and external payments position, since the main source of reserve money expansion are net RBI credit to government and net foreign exchange assets' (Reddy 1999d). A critique of this statement would indicate the contradiction prevailing in the monetary policy regime of India. Once the target for broad money is fixed, why should the base money creation depend on anything else? However, since the RBI has another quantity control instrument in the form of variable CRR, it can moderate the effects of changes in base money on the growth of broad money due to policy responses to different factors such as the fiscal deficit, inflation and stabilization of the exchange rate. Therefore, in this context, it is important to examine the short and long run base money supply behaviour of the RBI and the effect of fiscal deficit in expansion of the monetary base. Policy instruments such as CRR and its effectiveness are analyzed in Chapter 8.

Figure 7.1 shows the distribution of sources of base money in India without taking into account the non-monetary liabilities[77] of the RBI, which should be subtracted to match the accounts. Clearly the RBI credit to government[78] has dominated the sources of base money supply over the sample period and more recently foreign exchange reserves has also become major source of money supply. The other sources of base money supply are the RBI credit to commercial sector[79], gross RBI claims on banks[80] and government currency liability to public[81]. Thus, the RBI holding of government securities and the net foreign exchange assets form the main assets of the RBI. Changes in these assets result in changes in the base money stock.

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[76] Speech at the Fourth Securities Industry Summit, organized by Invest India Pvt. Ltd., at Mumbai, on May 26, 1999

[77] Non-monetary liability is inclusive of appreciation in the value of gold following its revaluation close to international market price effective October 17, 1990.

[78] Includes credit to both State and Central Governments.

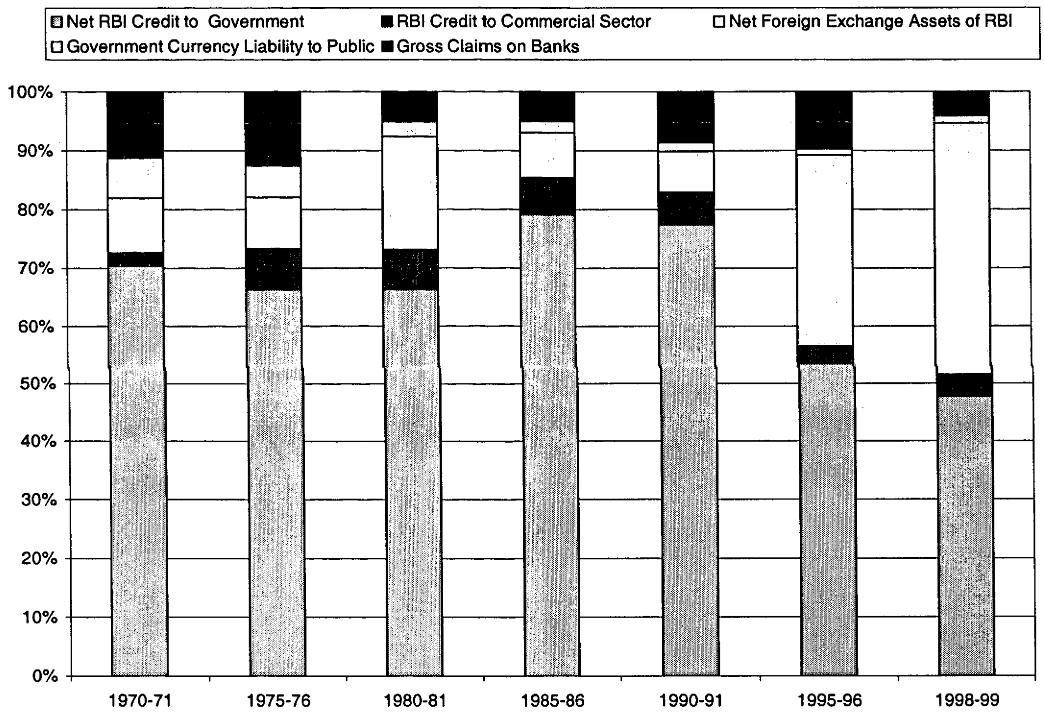
[79] Includes investments in bonds/shares of financial institutions, loans to them and holdings of internal bills purchased and discounted

[80] Includes commercial and cooperative banks and the National Bank of Agriculture and Rural Development

[81] Includes Government of India one rupee notes issued from July 1940.

Changes in the RBI assets can take place due to several activities including open market operations in government securities and foreign exchange reserves and that is what can be considered to constitute the base money supply behaviour of the RBI. Some of the actions of the RBI can be reactions to the changes in macroeconomic variables such as real exchange rate, interest rates, inflation and output. With inflation the real money wealth of the private sector falls and therefore private agents may exchange government bonds for money and consequently the RBI holding of government securities or the RBI credit to private sector or government may increase, thus increasing the base money. Part of this may result in seigniorage.

Figure 7.1 Distribution of the key sources of base money supply in India (1970-98)



Source: Based on Handbook of Statistics on Indian Economy, 1998 & 2000, RBI. All values are taken in rupees for calculating distribution. Non-monetary liabilities of the RBI are not considered.

However, financing of fiscal deficit and more recently private transfer of foreign money can be regarded as key reasons for the changes in sources of base money. Financing of fiscal deficit takes different routes in changing the RBI holding of government securities, credit to the commercial sector and gross claims on banks. When government borrows from the RBI and to the extent the fiscal deficit is monetized, base money is directly increased. When government borrows from the public and the commercial banks then also base money can increase, but in a complex way. For example, heavy government borrowing from the commercial banks and other financial institutions reduces credit for the private sector and may drive up interest rates. In such situation the commercial banks and other financial institutions may resort to borrowing from the RBI to meet their credit obligations and consequently base money may increase. In addition, in order to ease pressure on the interest rate the RBI may also buy back some of the government securities from the commercial banks and other private agents at higher prices and thus increasing the base money.

Therefore, the fiscal deficit has a direct as well as an indirect impact in increasing base money and its overall effect needs to be estimated because it cannot be accounted as an identity.

Private transfers of foreign money by non-resident Indians poses specific problem for the RBI in controlling base money as discussed in Chapter 5. Particularly, such money impedes the control of the RBI on base money expansion in direct (when foreign exchange routes through the RBI) as well as indirect (when it routes through commercial banks) ways.

Two questions are addressed in the following paragraphs. First, how robust is the fiscal deficit as a source of base money expansion? Second, how far the variation in the base money stock represents reaction and passive accommodation to the changes in output, exchange rate, inflation and interest rate? The fiscal deficit is used as the key variable to identify the supply functions for base money in an error correction specification to allow analysis of both the short and long run effects. Permanent real income (YP), as defined in Chapter 4, and current real income (Y) are used as alternative proxies for real activity. Thus, equations (7.12) and (7.13) present two alternative specifications of base money supply. Estimation of base money supply behaviour in alternative ways will allow examination of the robustness of fiscal deficit as the cause of base money expansion.

Alternative-I uses the scale variables of output (or permanent income) and fiscal deficit and price variables like the real exchange rate and interest rate, to which the RBI is expected to react. The second alternative uses a quantity variable like foreign exchange reserves and fiscal deficit along with another scale variable.

Alternative – I

$$m0 = f\,(scale\ \mathrm{var}\,iable, fiscaldeficit,\ price\,level,\ real\,exchangerarte,\ \mathrm{int}\,erest\ rate) \quad (7.12)$$

Alternative – II

$$m0 = f\,(scale\ \mathrm{var}\,iable, fiscaldeficit,\ price\,level, foreign\,exchange\,reserves) \quad (7.13)$$

Price index is included in both alternatives, because modeling is done with nominal base money stock without imposing the homogeneity assumption (see Chapter 6 on the fragility of this assumption).

As explained in Chapter 4, the combined gap between total outlay and total current revenue of state and central government and public sector undertakings, taken as a fraction of gross domestic product (CGAPZ) proxy fiscal deficit in this study and wholesale price index (P) proxy the price level. The real exchange rate (REER) is a constructed variable with trade weights of five major trading partners of India such that an increase indicates appreciation (see Appendix AA of the thesis for more details on constructed data). Yield on 1-5 year central government securities (CGS1) proxy interest rate. The quantity of foreign exchange reserve (FERU) is taken in US Dollars. As usual, all variables taken in logs are expressed in small letters and a Δ prefix indicates the variable is taken in first difference.

Examination of the ADF based unit root test of time series indicates that the variables of $m0$, $reer$, CGS1, p, y, $feru$ and CGAPZ are all integrated of order one and yp is also integrated of order one when trend is included in the ADF test (details of the test results are provided in Annexure 7.2 of this chapter). Therefore, as followed in the previous two chapters, a cointegration-based analysis of the long-term relationship is considered preferable. Considering key variables are trended, the cointegration is tested in a VECM specification with restricted trend and unrestricted intercept, as explained in Annexure 5.3, Chapter 5 and Appendix AB of this thesis.

The structural design of the cointegrating vectors allows testing the significance of the trend term in final specification of the long run relationship. The error term obtained from the long-run relationship represents the disequilibrium behaviour. The short-term dynamics of base money supply is modeled in the second step using error from the long-term relationship and first difference of other variables. The rest of this section is organized as follows. The base money supply behaviour based on fiscal deficit, the real exchange rate and the interest rate (alternative model-I) is first examined in section 7.3.1 and that based on fiscal deficit and foreign exchange reserves (alternative model-II) in section 7.3.2. As prefaced in Chapter 4, the long-term effect of fiscal deficit on economic growth will be analyzed in section 7.3.3 and finally policy implications and concluding remarks are presented in section7.4.

7.3.1 Base Money Supply Behaviour: Alternative Model-I

Considering that key variables are trended, the cointegration is tested with restricted trend and unrestricted intercept and the results presented in Annexure 7.3 and summarized in Table 7.3. The structural design of the cointegrating vectors allows deletion of the trend term from the final specification of the long run relationship (see Annexure 7.4 for details) in both cases with Y and YP. This is an important result, which is possibly obtained due to the inclusion of fiscal deficit and real exchange ratein the money function. It may be recalled from the results and discussion in Chapter 6 that trend was a significant variable in the long-run relationship of base money which appears to have been capturing the effects of supply variables like fiscal deficit.

The estimated long-term relationship between base money, price, output, exchange rate and fiscal deficit is given below in Table 7.3 in two versions, one with real output and the other with real permanent income. The deviations from the long-run relationships are captured by ERM0A and ERM0B for model with Y and YP, respectively. The asymptotic standard errors of the long-term coefficients are given in parenthesis.

Table 7.3 Selected long run equations for estimating alternative-I ECMs for supply of nominal base money M0

$$m0 = \underset{(0.809)}{8.42\,\text{CGAPZ*}} + \underset{(0.156)}{1.38\, y*} - \underset{(0.102)}{0.45\, reer*} - \underset{(0.441)}{1.53\,\text{CGS1*}} + \underset{(0.0695)}{0.649\, p*} + \text{ERSM0A} \qquad (7.14)$$

$$m0 = \underset{(0.860)}{9.50\,\text{CGAPZ*}} + \underset{(0.178)}{1.308\, yp*} - \underset{(0.115)}{0.55\, reer*} - \underset{(0.495)}{1.72\,\text{CGS1*}} + \underset{(0.076)}{0.608\, p*} + \text{ERSM0B} \qquad (7.15)$$

Note: See Annexure 7.4 of this chapter for the structural design of the cointegrating vector. Values in parenthesis () are asymptotic standard errors. *significant at 1% level, **significant at 5% level and ***significant at 10% level

All the variables in the model are significant at the one percent level. The coefficient on the price term is significantly below one, which shows that the supply for real base money falls with inflation and the RBI does not fully accommodate inflation in the long-term. However, the sign of coefficients on other variables do not suggest that long-term supply of base money is a result of reaction to changes in output or real exchange rate or interest rate. In the long run, supply of base money increases with increasing output level or permanent income, increasing fiscal deficit, and an increase in the price of government securities, while the monetary authorities tend to accommodate part of currency appreciation. This shows a passive money supply.

However, the coefficient on the output term in equations (7.14) and (7.15) may be argued to represent the actual elasticity of base money demand with respect to real activity. This can be used to determine the demand for money due to real activities. If this hypothesis is accepted, the elasticity of broad money M3 can be calculated after adding the expected growth in broad money multiplier to the income elasticity of base money, which is 1.38. However, since the broad money multiplier is not constant, it is harder to target broad money. The average growth (in fraction) in broad money multiplier during the sample period has been about 0.02 with standard deviation of 0.046 and coefficient of variation of 2.44. Adding 0.02 to 1.38, the income elasticity of broad money is obtained as 1.40, which is less than 1.58, the value considered by the RBI (see discussion in Chapter 6). But, in view of the high coefficient of variation in multiplier, this too may not be reliable.

In the case of narrow money also, the average growth (in fractions) of narrow money multiplier during the full sample period has been –0.01 with standard deviation of 0.057 and coefficient of variation of about 7, which is much higher. Thus targeting any of the broader aggregates require precise forecasting about the multiplier growth. However, it can be argued in this context, based on the estimation results of the previous section that the narrow money multiplier (mm1) being more precisely estimated, qualifies M1 as a better aggregate for targeting compared to broader aggregate. Further, for the period beyond 1976, the narrow money multiplier exhibits mean reversion as against the broad money multiplier, which remains non-stationary (see Chapter 6).

Coming back to the other variables in equations (7.14) and (7.15), the negative signs of bond and real exchange rate suggest the RBI's counter measures against inflationary expectations rather that reaction to changes in interest and real exchange rates. A high nominal interest rate may represent inflationary expectations, which also has a tendency to appreciate the real exchange rate. Therefore, in order to counter the expected inflation base money growth is reduced. It may also be noted that the effects of fiscal deficit and the price of government securities have an institutional relationship. With a high fiscal deficit the government resorts to heavy borrowing from the commercial banks resulting in a loss of liquidity for directed credit and possibly an increase in lending rates to the private sector. The government may impose its security on the banks at a high price. Therefore, the RBI might be helping banks by buying back government securities at a high price. With most commercial banks in the public sector and the RBI under the influence of government, such possibilities also exist.

The negative sign of the exchange rate also implies that in long-run there is no currency substitution. Rather, it is the need for meeting the imports bill that determines the money demand in exchange of foreign currency, which the RBI keeps accommodating allowing a controlled depreciation of currency.

The effect of fiscal deficit on the long-run growth of base money is quite high. Considering equation 7.15 (Table 7.3), at 10 percent level of fiscal deficit, each percentage point increase leads to about 0.95 percent growth of base money. This growth may be either due to direct accommodation or indirect operations of the central bank when it tries to create money under the fear of an interest rate rise in the face of heavy government borrowing.

The short-run dynamics of the base money supply corresponding to both the error terms discussed above are presented in Table 7.4 as models SM0A and SM0B corresponding to the two error terms of ERSM0A and ERSM0B, respectively, in Table 7.3. The error terms in both models, SM0A and SM0B are significant with high negative value, indicating quick adjustments for long-term deviations.

The sign and size of coefficients of all variables are similar in both models but the explanatory power of model SM0B is superior to model SM0A and the SM0B model encompasses SM0A in a non-nested test. Model SM0B has a high R-bar square of 0.84, with acceptable statistical properties. There was no structural break in the CUSUM and CUSUM of squares test. Thus, permanent income appears to be a better scale variable in explaining the supply of base money.

Table 7.4 Models of nominal base money supply: alternative-I (1972-98)

Dependent Variable	$\Delta m0$	$\Delta m0$
Model number	SM0A	SM0B
INTERCEPT	-19.91 (2.639)*	-17.334 (1.940)*
ERSM0A (-1)	-1.579 (0.208)*	
ERSM0B (-1)		-1.509 (0.1684)*
$\Delta m0$ (-1)	0.2547 (0.1215)**	0.127 (0.103)
Δy	0.966 (0.2606)*	
Δyp		2.242 (0.420)*
Δyp (-1)		1.415 (0.374)*
Δp	0.8697 (0.1857)*	0.851 (0.162)*
ΔCGS1	-2.068 (0.388)*	-1.890 (0.329)*
ΔCGS1 (-1)	0.793 (0.408)***	1.101 (0.358)*
ΔCGAPZ	3.532 (0.747)*	4.027 (0.649)*
ΔCGAPZ (-1)	-3.931 (1.127)*	-3.946 (1.001)*
$\Delta reer$ (-1)	0.4089 (0.143)**	0.417 (0.124)*
R-Square	0.86	0.903
R-Bar-Square	0.78	0.843
S.E of Regression	0.029	0.024
Diagnostic Tests		
DW-statistics	2.09	1.90
LM (3) serial correlation	1.92 [0.59]	2.65 [0.45]
ARCH (3) test	2.02 [0.57]	1.96 [0.58]
Functional Form CHSQ (1)	1.12 [0.29]	1.30 [0.25]
Normality CHSQ (2)	1.99 [0.37]	1.19 [0.55]
Predictive failure CHSQ (6)	4.14 [0.66]	2.79 [0.83]
Stability test CHSQ (10)	3.84 [0.95]	
Stability test CHSQ (11)		4.10 [0.97]
Residual Unit root test		
Test statistics (DF)	-5.12	-4.70

Notes: Predictive failure test is conducted by breaking the sample at 1992; the stability test is conducted by breaking the sample at nearest past as permitted by the number of regressors in the equation. Unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

The coefficient of the inflation term Δp is positive but not significantly different from one, which means that in the short-run the RBI almost fully accommodates the changes in prices. On the other hand, the coefficient of lagged exchange rate growth is positive, which means that in the short run the RBI has a tendency to control money in the face of currency depreciation although in the long-term it allows the currency to depreciate. This is the only clear-cut reaction in the short-run base money supply. This also means that in the short run the central bank buys foreign currency whenever the domestic currency appreciates in order to boost foreign exchange reserves. The instantaneous effect of increase in the fiscal deficit is significantly positive, which propagates in a cyclical pattern and ultimately increases the base money supply permanently in the long run. In the case of interest rate it can be argued that an increase in the interest rate indicates inflationary expectations, which prompts money supply to instantaneously contract.

From the foregoing discussion it is difficult to forcefully conclude that base money growth is a result of reactions to changes in goal variables rather than accommodation of the changes. On the other hand, fiscal dominance is more clearly demonstrated. Whether, fiscal dominance is robust to change in the specification of the base money supply function is examined in the following subsection.

7.4.2 Base Money Supply Behaviour: Alternative Model-II

In light of the observations of Reddy (1999d) mentioned earlier, the base money supply can be examined by estimating base money using those variables, which are linked to the sources of base money supply, particularly the fiscal deficit and foreign exchange reserves. The quantity of foreign exchange reserve (FERU) is taken in US Dollars. FERU is expressed in log, and is integrated of order one, while its first difference is stationary. All other variables are explained earlier. The modeling technique adopted is the same as above. Test of cointegration and the design of cointegrating vector are presented in Annexure 7.3 and 7.4.

The long run relationship is obtained from a VECM specification of order one, while the short-run model in error correction specification is obtained in the second step. The trend and price terms are not retained in the vector considering the result of LR test of over identifying restrictions (see Annexure 7.4, model SM0C). The null hypothesis of zero coefficients of trend and price terms jointly is accepted at 4.9 percent significance level in view of the fact that LR test has a tendency to over-reject the null hypothesis. Moreover, an almost identical vector is obtained when the test is carried out with unrestricted intercept and no trend. Therefore, a vector with joint restriction on price and trend is accepted. The corresponding long run relationship is presented in equation (7.16) while the error correction model is presented in Table 7.5.

$$m0 = 9.80\ \text{CGAPZ}^{*} + 2.42\ yp^{*} + 0.102\ feru^{*} - 0.00\ p - 0.00\ \text{T} + \text{ERSM0C} \quad (7.16)$$

(1.570) (0.111) (0.032)

Note: See Annexure 7.4 of this chapter for the structural design of the cointegrating vector. Values in parenthesis () are asymptotic standard errors. *significant at 1% level, **significant at 5% level and ***significant at 10% level

It can be noted from equations (7.14), and (7.15) in Table 7.3 and equation (7.16) that the long-term coefficient of fiscal deficit is almost same across models. This clearly brings out a robust long-term influence of fiscal deficit on the process of money creation. The average growth rate of base money for the sample period has been about 14.2 percent, which appears to be consistent with the 4.6 percent growth rate of permanent income, the 12 percent growth rate of foreign exchange reserves and the average annual 0.18 percentage point change in the fiscal deficit as a share (in fraction) of GDP.

The full-sample-period error corrected estimation of base money supply is presented in model SM0C (Table 7.5), where equation (7.16) has been used to obtain the error correction term ERCM0C. The signs of the variables are all in line with the idea of reserve creation by the RBI. If the foreign reserve is more, the RBI finds it convenient to increase reserve money, while accommodating increases in the fiscal deficit by holding government securities. It is important to discuss how this model and particularly the coefficients of the foreign reserve and fiscal deficit perform over time.

It can be noticed that model SM0C fails in a predictive failure test at 1992, which is considered a benchmark year for testing the predictive failure in this study because it represents the year when financial reforms began to take shape. SM0C fails in predictive failure test for most periods before 1993. However, the coefficients are stable (see Chows second test of stability). The predictive failure occurs because of lesser 'in sample predictive error' for the period prior to 1993. Therefore, estimations for the truncated periods, 1971-90, 1971-92 and 1971-93 are also presented, while keeping the same long-run relationship.

Important conclusions can now be drawn related to the role of fiscal deficit and foreign exchange reserves as sources of money supply. With the same variables in the models, the R-square of model SM0C3 is 0.76 compared with 0.58 in model SM0C, which includes the post reform period. The coefficients of ΔCGAPZ and error correction term ERSM0C have decreased over time. Thus, the short-run response to the fiscal deficit is decreasing following gradual abolition of automatic monetization and it can be argued that fiscal dominance is beginning to reduce.

Table 7.5 Models of nominal base money supply: alternative -II (1971-98)

Dependent Variable	$\Delta m0$	$\Delta m0$	$\Delta m0$	$\Delta m0$
Model Number	SM0C	SM0C1	SM0C2	SM0C3
Regressor	4 (1971-98)	1971-93	(1971-92)	1971-90
INTERCEPT	-11.81* (2.478)	-12.80* (3.22)	-15.25* (3.033)	-19.85* (3.46)
ERSM0C (-1)	-0.446* (0.093)	-0.48* (0.121)	-0.576* (0.114)	-0.750* (0.130)
Δyp	3.295* (0.779)	3.396* (0.850)	3.181* (0.758)	3.29* (0.704)
Δp	0.541** (0.245)	0.609* (0.242)	0.612* (0.214)	0.731* (0.203)
$\Delta feru$	0.157* (0.040)	0.166* (0.045)	0.134* (0.042)	0.121* (0.040)
ΔCGAPZ	1.800*** (0.934)	2.596** (1.093)	2.677** (0.970)	3.830* (1.067)
R-Square	0.58	0.60	0.68	0.76
R-Bar-Square	0.48	0.48	0.58	0.67
S.E of Regression	0.044	0.044	0.04	0.036
Diagnostic Tests				
DW-statistics	2.38	2.00	2.33	2.30
LM (3) serial correlation	3.05 [0.38]	6.37 [0.10]	7.09 [0.07]	4.47 [0.22]
ARCH (3) test	0.23 [0.97]	0.61 [0.89]	1.11 [0.77]	4.62 [0.20]
Functional Form CHSQ (1)	0.68 [0.41]	0.74 [0.39]	0.57 [0.45]	0.03 [0.87]
Normality CHSQ (2)	1.28 [0.53]	3.11 [0.21]	0.71 [0.70]	0.01 [1.00]
Predictive failure CHSQ (2)	0.60 [0.74]			
Predictive failure CHSQ (5)	4.66 [0.46]			
Predictive failure CHSQ (6)	11.61 [0.07]			
Predictive failure CHSQ (8)	18.83 [0.02]			
Stability test CHSQ (6)	8.56 [0.20]			
Residual Unit root test				
Test statistics (DF)	-6.08	-5.26	-5.65	-5.37

Notes: Predictive failure test and parameter stability tests are conducted by breaking the sample at various points; unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with third order ADF. The error correction is obtained from equation 7.16. *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

The coefficient of $\Delta feru$ has increased over time whereas coefficients of all other variables have decreased. This is understandable, as India's foreign exchange reserves including gold, which stood at just under a billion US dollars in 1970 and just under six billion dollars in 1990, increased to more than 33 billion dollars by the end of 1999. This is a more comfortable situation from the point of view of meeting balance of payments obligations and providing psychological strength for the domestic currency, but at the same time throws up a challenging situation for monetary control, particularly when a large proportion of the foreign reserves is due to private transfers, which increased almost six fold between 1990 and 1999. This may be the reason behind predictive failure of this model.

The third observation is about the speed of adjustment, which has slowed. This emphasizes lower concerns for the long-term role of a stock variable like foreign reserves compared to the short-term concerns. The same is not true in the case of alternative model-I of determining base money stock with price variables like the interest rate and exchange rate, in which case the adjustments for deviations from long-run equilibrium take place quickly.

The above observations mean that considerations in creating base money are changing. While there is pressure from foreign exchange flows in the short-run, the long-term concerns are still dominated from fiscal deficit and other variables such as exchange and interest rates as reflected in more stable and robust models of base money supply such as SM0A and SM0B presented in Table 7.4. Models SM0A and SM0B have much better diagnostic and explanatory properties than the models in Table 7.5.

7.4.3 Long-term Effect of Fiscal Deficit on Economic Growth

The long-term effect of the fiscal deficit on economic growth can be calculated through its impact on inflation and investment. Money creation due to the fiscal deficit may add to an increase in inflation beyond the 5.5 percent level, which produces a negative effect on economic growth. On the other hand the fiscal deficit helps in motivating private investment. These two effects can be calculated to estimate the net effect of fiscal deficit at its various levels.

According to equation 7.15, the long-term elasticity of base money with respect to fiscal deficit (at a deficit of 10 percent) is 0.95. Considering the recent period of the 1990s, the average growth of the narrow money multiplier was 0.015. Therefore, the long-term elasticity of narrow money (at a fiscal deficit of 10 percent) will be 0.965. This means one percentage point of GDP increase in fiscal deficit above the 10 percent level adds to narrow money growth by 0.965 percent.

From inflation model INFB1, Table 5.14, Chapter 5, the long run effect on inflation of a one-percentage point increase in narrow money growth can be calculated as approximately 0.427 percentage points. The non-linear inflation model YPCC3, Table 4.4, Chapter 4 gives a negative effect of one percentage point increase in inflation above 5.5 percent as 0.16 percentage points. Thus the effect of one percentage point of GDP increase in fiscal deficit from the 10 percent level can be traced to economic growth through the inflation route as –0.066 percentage points (0.965*0.427*(-0.16) = -0.066). This is a substantial effect considering the fact that this is a perpetual effect on per capita income growth.

It may be recalled from Chapter 4 that in the long run the fiscal deficit has a positive effect on private sector investment. Each percentage point increase in the fiscal deficit contributed about a 0.72 percentage point increase in private investment. In the long run, each percentage point of private investment contributed to economic growth by about 0.06 percentage points although this effect is not significant. However, considering the fact that these coefficients are large, it may be pragmatic to account for their joint effect, which works out to be 0.043. Thus the total effect of the fiscal deficit on economic growth is still negative equal to –0.021 percentage points.

At a fiscal deficit of 6.5 percent, one percentage point GDP increase in fiscal deficit will have a negative effect on economic growth through inflation equal to 0.043 (=0.65*(0.066)), which evens out the positive effect of one percentage point GDP increase in fiscal deficit through investment. Therefore, it can be safely argued that the combined deficit should not increase beyond 6.5 percent of GDP, particularly if the inflation level is above the 5.5 percent. However, this does not mean the fiscal deficit can take any value if inflation is below the 5.5 percent level. Joshi (1998) and Joshi and Little (1996) calculate sustainable non-financial combined fiscal deficit of Center and State Governments as 7 percent with primary deficit being 1 percent of GDP. However, fiscal deficit of even 7 percent of GDP is argued to be high if the objective is to bring real interest rate substantially down to encourage private investment.

The above results have important implications in terms of efficacy of monetary policy. The fiscal dominance in money creation is clear. Inflation control requires a lower growth rate for narrow money and at the same time financial deepening requires a high multiplier. Both together require that the base money growth must be controlled, which seems a daunting task in the presence of a high fiscal deficit as discussed in Chapter 1. In a similar context of political economy, Sargent and

Wallace (1981) appear to suggest that if an irresponsible fiscal authority embarks upon a course of action that implies a continuous deficit net of interest, the monetary authority cannot control inflation by its own choice of base money creation. This message is important in the case where the fiscal authority moves first and has commanding power as assumed in their 1981 paper. However, if the monetary authority has a mandate to control inflation, it can take an independent course compelling the fiscal authority to expand its tax base or depart from the planned deficit or to face a crisis.

7.5 CONCLUSION AND POLICY IMPLICATIONS

The motivation for this chapter is drawn from the findings of the previous chapter, which concluded that the money-output relationship in the demand for money specification in India is very loose and any attempt to conduct monetary policy based on the paradigm of a stable demand for money is more likely to fail than succeed. Due to reasons such as the fiscal deficit, the discretionary supply of money has helped in loosening the money-output relationship when the money equation is specified as demand for money in Chapter 6. In this chapter, the supply behaviour of all three monetary aggregates has been analyzed from the perspective of the possibility of control on their growth. All three aggregates appear to be endogenous to macroeconomic variables. The models of money multipliers are well specified and it is possible to control money growth through policy instruments and institutional developments.

However, the critical problem arises due to endogeniety of base money growth. When the base money is specified like a supply equation, by including the fiscal deficit as an explanatory variable, it demonstrates better stability and predictive power. Permanent income obtained by error learning hypothesis comes out to be a better scale variable for explaining the supply behaviour of base money. The money supply increases with fiscal deficit and income. The base money supply equation appears to be a passive behaviour and there is less evidence of short run (or long run) reaction to output growth and inflation. There is some evidence of a short-run reaction to exchange rate change, but in the long run currency depreciation is also accommodated. Therefore, it is important to examine the reaction functions of the direct instruments of the RBI such as CRR and indirect instruments such as interest rates. Chapter 8 examines the RBI's policy stances with respect to such instruments, where consequences of passive supply of base money on the effectiveness of the policy stances with respect to instruments is also examined.

There is strong evidence of a long-term fiscal dominance in base money creation. This erodes the independence of monetary policy and hence limits its role in controlling inflation in India. However, there is some indication of reduction in fiscal dominance during the recent period of the 1990s. Therefore, one of the key requirements, mentioned in Chapters 1 and 3, of central bank independence for the success of a strict inflation targeting based monetary regime as practiced in developed countries, is not fully met in the case of India. However, this does not mean the RBI should not adopt inflation as the main goal of monetary policy. In fact both the RBI and the Central and State Governments of India should jointly commit to controlling inflation, as the long run effect of fiscal deficit is detrimental to economic growth, which works through the inflation channel.

Annexure 7.1 Summary definition of data used in Chapter 7

Symbol	Variable description and unit of measurement
BDR	Bankers' Deposits with RBI (rupees million).
CBDN	Bank density: population (thousands) per branch of commercial bank
CC	Currency in Circulation (rupees million).
CGAPZ	Fiscal Deficit: Combined GAP between Total Outlay and Current Revenue (CTO-CCR) of both Central and State Governments as fraction of gross domestic product.
CGS1	Bond rate: Annual yield on 1-5 Year government of India (GOI) Securities, taken in fraction. Middle point has been taken for the data given in range.
CIB	Cash on Hand with Banks (rupees million).
CMR	Overnight annual call money rate of commercial banks, taken in fraction
CRR	Cash Reserve Ratio: derived according to the RBI notifications as fraction of time plus demand deposits. Average of the notified values prevailing during the year.
CUP	Currency with the Public (rupees million).
DD	Demand Deposits with Banks (rupees million).
DR1	1-3 Year commercial banks annual deposit rates taken in fraction.
FERU	Gross international reserves (includes gold) measured in current US$ millions.
GDP	GDP at market prices at current prices (rupees million)
M0	Base (Reserve) Money (rupees million). M0 = CUP+CIB + BDR + ODR
M1	Narrow money (rupees million). M0 = CUP+CIB + BDR + ODR+DD
M3	Broad Money (rupees million). M3 = CUP + DD + TD + ODR
ODR	Other Deposits with RBI (rupees million)
P	Wholesale price index (WPI) of all commodities converted to base 1993-94
REER	Real Effective Exchange rate of G5 Countries defined such that an increase indicate appreciation
TD	Time Deposits with Banks (rupees million).
Y	Gross domestic product at constant market prices (rupees millions)
YP	Permanent real income calculated according to the error-learning hypothesis discussed in Ladler (1989:88) with geometric wt for last 10 years and weight of 0.5 for current year's real GDP at factor cost.

Annexure 7.2: Unit root tests for the variables used in Chapter 7 in levels and first differences (1970-98)

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend. 95% critical value	Statistic	AIC	SBC	The Dickey-Fuller regressions include an intercept and a linear trend 95% critical value	Statistic	AIC	SBC
CBDN	DF	-2.980	-6.68	-31.01	-32.26	-3.594	-2.01	-30.35	-32.24
	ADF (1)		-3.58	-31.67	-33.56		-1.92	-31.35	-33.07
ΔCBDN	DF	-2.985	-3.13	-34.06	-35.28	-3.603	-5.02	-29.70	-31.53
	ADF (1)		-2.60	-34.42	-36.25		-4.50	-29.86	-32.30
CGAPZ	DF	-2.980	-1.47	81.63	80.37	-3.594	-1.80	81.27	79.38
	ADF (1)		-1.18	81.71	79.82		-1.21	80.91	78.40
ΔCGAPZ	DF	-2.985	-7.24	80.43	79.21	-3.603	-7.47	80.42	78.59
	ADF (1)		-3.95	79.43	77.61		-4.23	79.46	77.02
CGS1	DF	-2.980	-1.23	69.22	67.96	-3.594	-1.48	68.69	66.81
	ADF (1)		-1.41	68.94	67.05		-2.00	69.09	66.58
	ADF (2)		-1.15	68.60	66.09		-1.48	68.25	65.10
ΔCGS1	DF	-2.985	-3.98	65.66	64.45	-3.603	-3.92	64.75	62.92
	ADF (1)		-3.95	65.61	63.78		-3.91	64.77	62.33
CRR	DF	-2.980	-1.68	77.54	76.29	-3.594	-0.74	76.54	74.66
	ADF (1)		-1.68	77.03	75.14		-1.37	76.44	73.93
ΔCRR	DF	-2.985	-4.41	76.10	74.88	-3.603	-4.26	75.23	73.40
	ADF (1)		-3.74	75.37	73.54		-3.66	74.57	72.13
CMR	DF	-2.980	-3.67	52.64	51.38	-3.594	-3.52	51.75	49.86
	ADF (1)		-3.84	52.52	50.63		-3.84	52.13	49.62
DR1	DF	-2.980	-1.71	85.73	84.48	-3.594	-2.99	87.77	85.89
	ADF (1)		-1.75	84.88	82.99		-4.74	91.64	89.12
	ADF (2)		-1.16	87.12	84.60		-3.18	90.67	87.53
ΔDR1	DF	-2.985	-4.55	80.47	79.25	-3.603	-4.55	79.78	77.95
	ADF (1)		-5.72	83.52	81.70		-5.70	82.91	80.47
	ADF (2)		-4.71	83.93	81.49		-4.61	83.22	80.18
feru	DF	-2.980	-1.67	-1.24	-2.50	-3.594	-1.90	-1.51	-3.39
	ADF (1)		-1.75	-0.84	-2.72		-2.42	-0.23	-2.74
	ADF (2)		-1.75	-1.70	-4.22		-2.68	-0.43	-3.58
Δ*feru*	DF	-2.985	-3.52	-1.93	-3.15	-3.603	-3.49	-2.81	-4.63
	ADF (1)		-2.60	-2.88	-4.71		-2.59	-3.77	-6.21
*m*0	DF	-2.980	-0.17	33.69	32.44	-3.594	-2.95	36.86	34.97
	ADF (1)		-0.15	32.71	30.82		-3.41	37.20	34.68
Δ*m*0	DF	-2.985	-4.93	32.06	30.84	-3.603	-4.83	31.08	29.25
	ADF (1)		-4.17	31.64	29.81		-4.09	30.68	28.24
mm1	DF	-2.980	-2.00	36.85	35.60	-3.594	-1.29	35.85	33.97
	ADF (1)		-2.06	36.24	34.35		-1.55	35.36	32.84
Δmm1	DF	-2.985	-4.18	33.35	32.13	-3.603	-4.36	33.07	31.24
	ADF (1)		-3.84	32.95	31.12		-4.17	33.08	30.64
mm3	DF	-2.980	-1.07	41.13	39.87	-3.594	-2.53	42.74	40.86
	ADF (1)		-0.98	40.17	38.28		-2.56	42.05	39.53
Δmm3	DF	-2.985	-5.20	38.87	37.65	-3.603	-5.09	37.88	36.05
	ADF (1)		-3.95	38.12	36.29		-3.86	37.14	34.70

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
p	DF	-2.980	-1.05	38.18	36.92	-3.594	-3.20	41.70	39.82
	ADF (1)		-0.92	37.90	36.01		-4.93	46.33	43.82
	ADF (2)		-0.93	38.80	36.28		-4.28	45.75	42.61
Δp	DF	-2.985	-4.10	38.41	37.19	-3.603	-3.97	37.41	35.58
	ADF (1)		-4.43	39.00	37.17		-4.29	38.01	35.57
	ADF (2)		-3.57	38.16	35.73		-3.47	37.18	34.14
$reer$	DF	-2.980	0.09	29.29	28.03	-3.594	-1.90	30.44	28.56
	ADF (1)		0.00	28.40	26.52		-2.02	29.85	27.34
$\Delta reer$	DF	-2.985	-4.44	28.14	26.92	-3.603	-4.37	27.21	25.39
	ADF (1)		-2.91	27.27	25.44		-2.84	26.31	23.87
y	DF	-2.980	1.24	53.29	52.04	-3.594	-2.13	54.93	53.05
	ADF (1)		1.58	52.98	51.09		-1.85	54.22	51.71
	ADF (2)		1.67	52.21	49.69		-1.71	53.34	50.19
Δy	DF	-2.985	-5.70	50.48	49.26	-3.603	-6.10	50.85	49.02
	ADF (1)		-3.83	49.48	47.65		-4.35	50.18	47.74
yp	DF	-2.980	3.31	71.96	70.70	-3.594	-1.03	71.99	70.11
	ADF (1)		2.34	71.01	69.12		-1.04	71.06	68.54
Δyp	DF	-2.985	-3.46	66.12	64.90	-3.603	-4.52	68.09	66.26
	ADF (1)		-2.69	65.22	63.40		-3.92	67.61	65.17

Note: ADF = Augmented Dickey Fuller. AIC = Akaike Information Criterion. SBC = Schwarz Bayesian Criterion of model selection. The order of ADF test is chosen as 2 in all the cases. Number of observations varies from 25 to 26.

Annexure 7.3: Test results for cointegration between variables in alternative functions of nominal base money supply (reference tables: 7.3 to 7.5) (1971-98)

Maximum Eigenvalue Test					Trace Test					No. of vectors Selected
Hypothesis		Statistic	Critical values		Hypothesis		Statistic	Critical values		
Null	Alternative		95%	90%	Null	Alternative		95%	90%	
Model SM0A: Variables set: m0, y, p, reer, CGAPZ, CGS1, Trend. **Eigenvalues:** 0.86607, 0.60302, 0.54063, 0.49769, 0.39428, 0.30512, 0										
r = 0	r = 1	56.2913	43.61	40.76	r = 0	r = 1	147.45	115.85	110.60	1
r<= 1	r = 2	25.8685	37.86	35.04	r<= 1	r<= 2	91.16	87.17	82.88	
r<= 2	r = 3	21.7809	31.79	29.13	r<= 2	r<= 3	65.29	63.00	59.16	
Model Ref. SM0B: Variables: m0, yp, p, reer, CGAPZ, CGS1, Trend. **Eigenvalues:** 0.86954, 0.65265, 0.5365, 0.46755, 0.425, 0.3395, 0										
r = 0	r = 1	57.01	43.61	40.76	r = 0	r = 1	152.90	115.85	110.60	1
r<= 1	r = 2	29.61	37.86	35.04	r<= 1	r<= 2	95.89	87.17	82.88	
r<= 2	r = 3	21.53	31.79	29.13	r<= 2	r<= 3	66.29	63.00	59.16	
Model Ref. SM0C: Variables: m0, yp, p, feru, CGAPZ, Trend. **Eigenvalues:** 0.78895, 0.6084, 0.50829, 0.4361, 0.14266, 0										
r = 0	r = 1	43.56	37.86	35.04	r = 0	r = 1	110.04	87.17	82.88	1
r<= 1	r = 2	26.25	31.79	29.13	r<= 1	r<= 2	66.48	63.00	59.16	
r<= 2	r = 3	19.88	25.42	23.10	r<= 2	r<= 3	40.23	42.34	39.34	
Model Ref. SM0C1: Variables in VAR m0, yp, feru, CGAPZ, Trend. **Eigenvalues:** : 0.67895, 0.45095, 0.37644, 0.1442, 0										
r = 0	r = 1	31.81	31.79	29.13	r = 0	r = 1	66.19	63.00	59.16	1
r<= 1	r = 2	16.79	25.42	23.10	r<= 1	r<= 2	34.37	42.34	39.34	
r<= 2	r = 3	13.22	19.22	17.18	r<= 2	r<= 3	17.58	25.77	23.08	

Note: All tests are done applying likelihood ratio test on the maximum eigenvalue and trace of the stochastic matrix in VECM specification with restricted trend and unrestricted intercept. Period: 1971-98, Order of VAR = 1.

Annexure 7.4 Structure of the cointegrating vectors for modeling supply of nominal base money (reference Tables 7.3 to 7.5) (1971-98)

Model – SM0A: List of variables included in the cointegrating vector: m0, y, p, reer, CGAPZ, CGS1, Trend, Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.

Imposed Restriction: a1=1

	m0	CGAPZ	y	reer	CGS1	p	Trend
Vector: a	1.000	-8.259*	-1.343*	0.444*	1.516*	-0.614*	-0.005
Std. Error	(NONE)	(1.446)	(0.307)	(0.110)	(0.449)	(0.272)	(0.038)

Imposed Restriction: a1=1; a7=0

	m0	CGAPZ	y	reer	CGS1	p	Trend
Vector: a	1.000	-8.4156*	-1.3789*	0.4493*	1.5295*	-0.64903*	0.000
Std. Error	(NONE)	(0.8092)	(0.15601)	(0.10234)	(0.441)	(0.0695)	(NONE)

LL subject to exactly identified restrictions = 383.51. LR test of additional restriction (a7=0): CHSQ (1) = 0.01766[0.894], LL subject to over identified restrictions = 383.50

Model – SM0B: List of variables included in the cointegrating vector m0, yp, p, reer, CGAPZ, CGS1, Trend, Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.

Imposed Restriction: a1=1

	m0	CGAPZ	yp	reer	CGS1	p	Trend
Vector: a	1.000	-8.183*	-1.013*	0.519*	1.660*	-0.3704	-0.037
Std. Error	(NONE)	(1.577)	(0.361)	(0.114)	(0.467)	(0.268)	(0.040)

Imposed Restriction: a1=1; a7=0

	m0	CGAPZ	yp	reer	CGS1	p	Trend
Vector: a	1.000	-9.4975*	-1.3077*	0.55451*	1.7177*	-0.60751*	0
Std. Error	(NONE)	(0.86)	(0.1784)	(0.1154)	(0.495)	(0.0755)	(*NONE*)

LL subject to exactly identified restrictions = 400.16. LR test of additional restriction (a7=0): CHSQ (1) = 0.785[0.38], LL subject to over identified restrictions = 399.77

Model – SM0C: List of variables included in the cointegrating vector: m0, yp, p, feru, CGAPZ, Trend. Period: 1971- 98, Order of VAR = 1, Selected number of vectors =1.

Imposed Restriction: a1=1

	m0	CGAPZ	yp	feru	p	Trend
Vector: a	1.000	-28.85	-7.865	-0.3030	-2.838	0.5411
Std. Error	(NONE)	(21.15)	(5.6117)	(0.2434)	(2.431)	(0.524)
Imposed Restriction: a1=1; a5=0; a6=0						
Vector: a	1.000	-9.79*	-2.4218**	-0.1016*	0.000	0.000
Std. Error	(NONE)	(1.57)	(0.111)	(0.0316)	(NONE)	(NONE)

LL subject to exactly identified restrictions = 277.41. LR test of additional restriction (a6=0): CHSQ (1) = 5.640[0.018], LL subject to over identified restrictions (a6=0) = 274.59. LR test of additional restriction (a5=a6=0): CHSQ (2) = 6.051[0.049], LL subject to over identified restrictions (a5=a6=0) = 274.39

Notes: Values in parenthesis () are asymptotic standard errors. *significant at 1% level, **significant at 5% level and ***significant at 10% level.

Chapter 8

Monetary Policy: Reaction Function and Policy Effectiveness

8.1 INTRODUCTION

The analyses in the previous chapters form a basis for conducting monetary policy in India. The inflation process and the relationship of inflation with economic growth or output gap do not support the existence of a robust trade-off. Chapter 5 found a lagged output gap had a positive effect on inflation, which indicated the existence of an upward sloping short run Phillips curve, but that relationship failed with the inclusion of important variables describing the inflation process. However, the robust negative relationship between the contemporaneous output gap and inflation predominantly supports the view that inflation in India was considerably affected by supply shocks. Therefore, growth arising from productivity improvements and favourable weather conditions may not be inflationary.

Without any short run trade off between inflation and output, there should be no dilemma for the central bank (see Reddy (1999d) for such apprehensions and dilemma) in setting priorities. Keeping inflation at a low level should be the primary target for monetary policy in India. As many central banks and economists have canvassed, it is preferable for there to be only one goal for monetary policy and that goal should be inflation stability if not price stability. Regarding the vital question of whether the monetary authorities in India could adhere to this single goal, the answer emerging from the analysis in the earlier chapters is in the affirmative.

It is observed that the growth of narrow money has contemporaneous as well as lagged effects on inflation. It is also seen that base money, which can be used to control narrow money is significantly explained by contemporaneous inflation. This probably indicates the RBI's responses to accommodating inflation. However, that this accommodation has been significantly less than full in the long run also indicates the RBI's concern regarding inflation. As mentioned in Chapter 1, the stated objective of the RBI is to help output growth through the adequate creation of credit whilst maintaining a reasonable control on inflation.

Whether the RBI has been more concerned with output growth or inflation is an empirical question addressed in this chapter by analyzing the policy instruments in the hands of the RBI. The analysis is in two parts. First, the policy reaction functions have been modeled to see how policy stance decisions respond to the changes in goal variables. In the second part, the transmission effects of RBI's policy stances on goal variables have been analyzed using causality tests, impulse responses in VARs, and analysis of simple estimated models of relevant variables.

This chapter is organized as follows. In following section 8.2, plausible policy rules are estimated. Section 8.3, examines the role played by monetary instruments such as the cash reserve ratio (CRR), Central Government Securities (CGS1), and call money rate (CMR) on the goal variables during the sample period. Concluding remarks are presented in section 8.4.

8.2 ESTIMATION OF POLICY VARIABLES

Modern central banks are concerned with the real interest rate because the transmission of monetary policy takes place by affecting the demand side variables such as investment and consumption, which depend on the expected real interest rate. The central bank meets its objective of controlling the real interest rate by either injecting or draining high-powered money through open market operations in the financial markets or by announcing their intent. The interest rate procedure of central banking does not target any particular money aggregate, but is concerned with manipulating the money supply in such a way that the interest rate takes a value that the central bank desires and perceives to be optimal for hitting the targets of goal variables. Accordingly, researchers have designed and estimated the reaction functions of central banks with some interest rate as the functions of desired goal outcome or target variables (see discussion on policy rules in Chapter 3).

The main instrument for conducting monetary policy in India has been the cash reserve ratio (CRR). Interest rate instruments are also available but unlike the case in developed countries they have not been fully market determined, and are therefore considered comparatively less effective.[82] Following implementation of the financial reforms in 1991, and since 1993, the RBI introduced several other interest rate instruments, such as 91 days treasury bills, 180 days TB, 365 days TB and repo. Efforts are being made to groom interest rates as a monetary policy instrument.[83] However, the RBI can also conduct its policies through a quantity control instrument like the CRR without changing the base. By increasing the CRR, the RBI is able to reduce the multiplier and influence broader aggregates like broad money (M3) and narrow money (M1), which, in turn, affect inflation and output growth, which are the stated goal variables of the RBI.

In view of the persistent current account deficit, the response of the exchange rate to adjustments in the instruments may also be an important consideration of policy stance. Therefore, the real exchange rate has also been included in the models of instrument rule. Thus, in this analysis, output growth, inflation and real exchange rate change are considered to be the variables of interest.

For the purpose of the policy analysis in this thesis, the central bank's reaction functions with the call money rate (CMR), yield on short-run (1-5 years) Government of India's security (CGS1), and cash reserve ratio (CRR) have been estimated in two versions. The first is in the tradition of the Taylor (1993) type rule with forward-looking behaviour suggested in a recent paper by Clarida, et al. (1998). The second method is a simple backward looking error correction estimation of the instrument variable with goal variables as the explanatory variables. The justification for such specification follows. It may be noted that the CMR is more about the liquidity constraints of commercial banks taking overnight loans from each other. It has a signaling effect for central bank policy actions on other instruments like the CRR and the stock of reserve money.

8.2.1 Policy Reaction Functions with Smoothing Behaviour

The model suggested by Clarida, et al. (1998) is modified to hypothetically estimate the probable monetary policy reaction function for India with respect to different

[82] It may be noted that the CRR can be classified as a direct instrument of quantity control, while interest rates can be classified as an indirect instrument.

[83] As the annual data series for the new interest rate instruments is too short to carry out a detailed analysis, the effectiveness of interest rate policy based on the monthly data for the period 1993-99 is examined by Singh and Kalirajan (2000), the VAR analysis indicates that the 91 days Treasury Bill rate is beginning to respond as a short run instrument.

instruments of CRR, CGS1 and CMR. The methodology suggested by Clarida, et al. (1998) is based on the deviations of inflation, output and other variables from their bliss (equilibrium) points. More specifically, it is based on expected deviations of actual from potential output, of expected inflation from the target and of the other variables of interest from their trend.

As pointed out earlier, in the case of a developing economy like India, policy stances are likely to be more concerned with the growth rate of output and so be more in reaction to deviations from expected growth rates. Further, due to persistent current account deficits, currency depreciation attracts immediate policy concerns. Therefore, the policy equation of Clarida, et al. (1998) is modified accordingly. Clarida, et al. (1998) consider forecasted inflation between quarters t and $t+n$ at alternative horizons (different n) to capture the concerns for real interest rate. There is no series available in India on expected inflation and for annual data current inflation is taken as future inflation. However, in line with their assumption, within each operating period the central bank sets a target for the nominal policy rate (CRR or interest rates) X*, based on the state of the economy. The target is assumed to especially depend on expected inflation, output growth and exchange rate change. Thus, the target rate of the central bank is written as follows:

$$X_t^* = \bar{X} + \alpha 1(E[\Delta p_t|\Omega_t] - \Delta p^*) + \alpha 2(E[\Delta y_t|\Omega_t] - \Delta y^*) + \alpha 3(E[\Delta z_t|\Omega_t] - \Delta z^*) \quad (8.1)$$

Here X-bar is the long-run equilibrium policy rate (CRR or CGS1 or CMR) taken in fractions; E the expectation operator; Ω_t the information set available to the central bank at the time of setting the policy rate; Δp_t the rate of inflation (in fractions); y real output; and z is a variable besides inflation and output that is of concern to the central bank. The bliss points for inflation, output growth and exchange rate change are represented by $\Delta p^*, \Delta y^*$, and Δz^*.

As mentioned above, z is the real exchange rate. Variables represented by a lower case letter are taken in log and a Δ before the variable indicates it is taken in first difference. Both, output and the real exchange rate are taken in log. Thus, the above equation represents the policy stance with respect to the deviation from the targets of expected growth, exchange rate change and inflation.

The central bank is supposed to follow smooth changes in policy rates to avoid disruption of the capital market and loss of credibility. In order to capture the smoothing factor, the partial adjustment of the policy variable is written as follows:

$$X_t = (1-\rho)X_t^* + \rho X_{t-1} + \upsilon_t \qquad (8.2)$$

Here, $\rho \in [0,1]$ is the degree of interest rate smoothing and υ_t is a white noise error. Combining (8.1) and (8.2) and letting $\beta = \bar{X} - \alpha 1\Delta p^* - \alpha 2\Delta y^* - \alpha 3\Delta z^*$ yields the following policy rule.

$$X_t = (1-\rho)(\beta + \alpha 1(E[\Delta p_t|\Omega_t]) + \alpha 2(E[\Delta y_t|\Omega_t]) + \alpha 3(E[\Delta z_t|\Omega_t])) + \rho X_{t-1} + \upsilon_t \qquad (8.3)$$

In order to obtain an estimable equation, the unobserved forecast variables can be eliminated by writing the policy rule (8.3) in terms of the realized variables as follows:

$$X_t = (1-\rho)(\beta + \alpha 1\Delta p_t + \alpha 2\Delta y_t + \alpha 3\Delta z_t) + \rho X_{t-1} + \varepsilon_t \qquad (8.4)$$

Now, ε_t, is a linear combination of the forecast errors of inflation, output growth and currency appreciation and the exogenous disturbance υ_t. Thus ε_t can be expressed as

$$\varepsilon_t = -(1-\rho)\{\alpha 1(\Delta p_t - E[p_t|\Omega_t]) + \alpha 2(\Delta y_t - E[\Delta y_t|\Omega_t]) + \alpha 3(\Delta z_t - E[\Delta z_t|\Omega_t])) + \upsilon_t$$

Under the assumption that ε_t is orthogonal to the information set of the central bank, equation (8.4) can be estimated using the non-linear least square technique.

A number of important inferences can be drawn from the sign and magnitude of the parameters α1 and α2 depending upon whether X is the interest rate or the CRR. If X is the nominal interest rate, then successful stabilization of output growth and inflation require that α1 is greater than one (α1>1) and α2 is positive. If α1 were less than one (with α2 >0), raising the nominal interest rate would not result in the rise in the real interest rate required for bringing down output growth. However, in the Indian context, there is a negative relationship between contemporaneous inflation and growth. Therefore, the values of α1 and α2 would need more careful interpretation, while discussing the results. Additionally, the above specification allows recovery of the target values of particular goal variables if the other targets are known using the following relationship. With a real interest rate rule, suppose the sample average of the real interest rate is taken as the long run equilibrium real interest rate $\overline{RR}$, then, the target inflation rate can be recovered[84] as $\Delta p^* = (\overline{RR} - \beta + \alpha 2 \Delta y^* + \alpha 3 \Delta z^*)/(\alpha 1 - 1)$. However, when the authorities do not follow the real interest rate rule, the implied target inflation rate can be obtained from the straight formula $\Delta p^* = (\overline{R} - \beta - \alpha 2 \Delta y^* - \alpha 3 \Delta z^*)/\alpha 1$, where an equilibrium nominal interest rate $\overline{R}$ is used. The latter relationship is more plausible in the Indian context, where CRR is the main instrument and interest rates may not be fully adjusted for the expected inflation.

While estimating equation (8.4), the ex-post realized value of average inflation during the year is considered the expected value of inflation. The values of the instruments are the average of the policy stances during the year. Similarly, the exchange rate is the average value for the year. All the variables are tested for unit root. CRR and CGS1 are integrated of order one, while CMR and goal variables are stationary. Therefore, the residuals from the estimations are tested for statistical consistency. As explained in Chapter 7, the exchange rate is five-country trade weighted foreign currency price of domestic currency (see Appendix AA for details). An increase in the value of the exchange rate means appreciation of the domestic currency. A lagged value of exchange rate change is also included in the estimation equation. The estimation results for the three chosen instruments are presented in Table 8.1, while the plots of their actual and fitted values are presented in Figures 8.1 to 8.3. Two important observations can immediately be made from the plots of the fits. First, CRR is better explained than the CGS1 and CMR. Second, both CRR and CGS1 fit quite well for the post reform period in comparison to CMR.

General observations from the results of Table 8.1 are as follows. From the coefficients of ρ, it is clear the central bank is more concerned with smoothing the CGS1 and the CRR than with the CMR. However, the CMR captures the effects of inflation and real exchange rates more significantly than CGS1. These reactions in the call money market could be due to the policy stances taken by the central bank on

[84] This is conditional on the data not containing disinflation episodes. In the Indian context there was only one such episode.

CRR. With regard to the explanatory power of the models, CRR clearly appears to be more precisely estimated than the interest rates. As CRR has been a more effective tool than interest rates, this is in line with expectations. Regarding the size of the coefficient of inflation, $\alpha1$ in the interest rate equations is less than one in both cases, which means the central bank has not been following any kind of real interest rate target for the economy. This is not surprising given that the RBI loosely targets broad money through the application of quantity control rather than the interest rate. The β coefficient is not at all significant in any of the equations. This means there is no strong linkage between the targeted values of the goal variables and the long run average values of the instruments.

Table 8.1 Non-linear models of policy instruments with smoothing behaviour

Non-linear Regression Formula:

$$X = (1-\rho)*[\beta+\alpha1*\Delta p+\alpha2*\Delta y+\alpha3*\Delta reer+\alpha4*\Delta reer(-1)]+\rho*X(-1)$$

Dependent Variable X	Cash reserve ratio (CRR)	Average yield on 1-5 years Treasury Bill (CGS1)	Average inter-bank call money rate (CMR)
Regressor coefficients	1972-98	1972-98	1971-98
ρ	0.806 (0.057)*	0.794 (0.102)*	0.343 (0.174)***
β	-0.030 (0.042)	-0.003 (0.059)	0.029 (0.032)
α1	0.643 (0.281)**	0.565 (0.405)+	0.564 (0.249)**
α2	1.031 (0.396)**	0.549 (0.575)	0.218 (0.294)
α3	-0.372 (0.183)***	-0.511 (0.294)***	-0.363 (0.149)**
α4	-0.450 (0.164)*	-0.245 (0.224)	
R-Square	0.94	0.87	0.42
R-Bar-Square	0.93	0.84	0.32
S.E of Regression	0.01	0.02	0.03
F-statistics F (k-1, n-k)	71.62 [0.00]	27.87 [0.00]	4.12 [0.01]
Diagnostic Tests			
LM (1) serial correlation	0.03 [0.87]	0.60 [0.44]	0.63 [0.43]
LM (3) serial correlation	2.77 [0.43]	3.58 [0.31]	6.08 [0.11]
ARCH (3) test	1.97 [0.58]	0.44 [0.93]	3.48 [0.32]
Functional Form CHSQ (1)	0.58 [0.45]	5.37 [0.02]	1.40 [0.24]
Normality CHSQ (2)	0.19 [0.91]	0.77 [0.68]	4.57 [0.10]
Residual Unit root			
Test statistics (DF)	-4.40	-4.17	-6.01

Note: unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level, +significant at 20 percent; values in parenthesis () are standard errors and values in square brackets [] are p-values. In F-statistics k is number of regressors including intercept and n is the number of observations.

Figure 8.1 Actual and fitted values of CRR (1972-98)

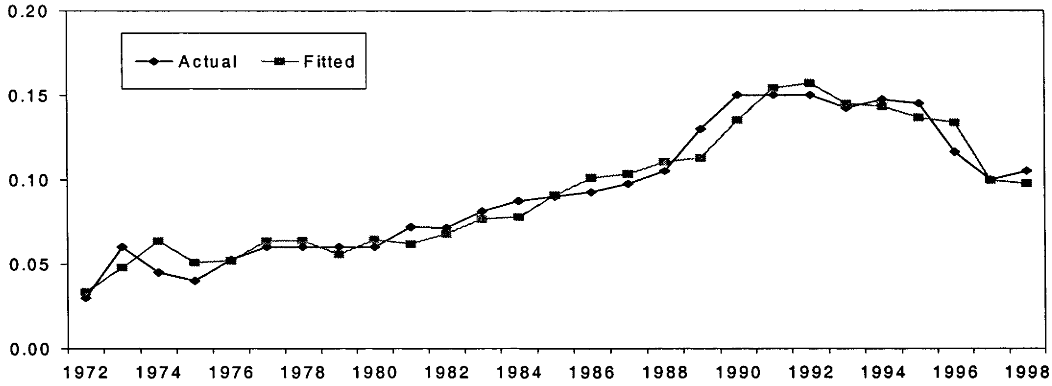


Figure 8.2 Actual and fitted values of CGS1 (1972-98)

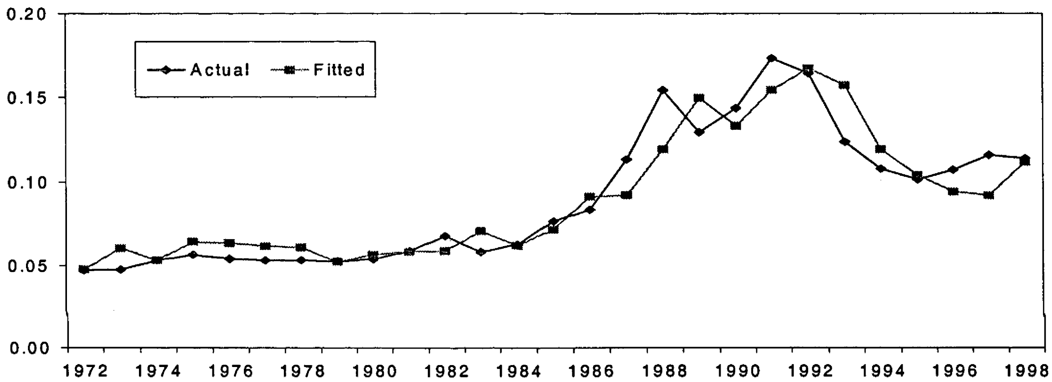
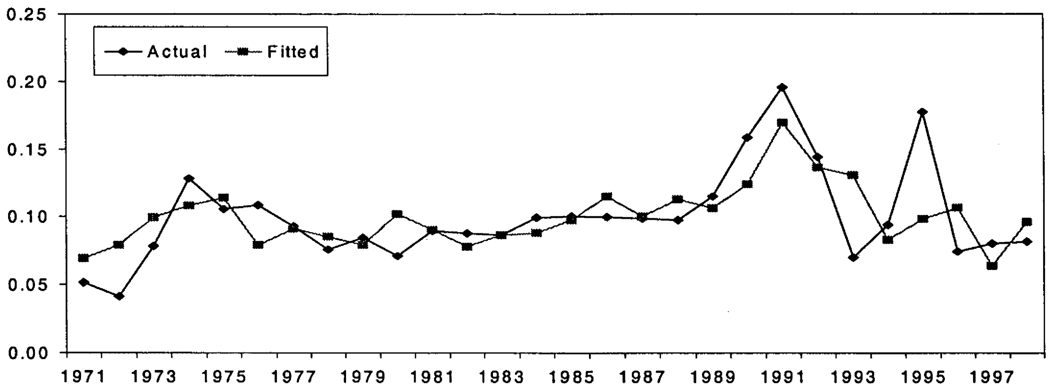


Figure 8.3 Actual and fitted values of CMR (1971-98)



Most of these observations are not encouraging, as the data does not demonstrate the desired sophistication imbedded in modern central banking in developed countries, where financial markets are highly developed allowing for application of the interest rate channel of policy transmission all the time. Nevertheless, this does not prevent further analysis.

Considering the CRR policy first, all the three goal variables are significant. An increase in inflation prompts the CRR to be raised in order to reduce the money supply causing the aggregate demand schedule to shift backwards and reduce inflation. The results in Table 8.1 also indicate a positive and significant relationship between output growth and the CRR. This implies that when output growth is expected to fall, the CRR is reduced in order to increase the credit-creation capacity of commercial banks.

The coefficient of inflation is 0.64 compared to 1.03 for output growth. This means that to increase output growth by one unit, CRR has to be reduced more than it has to be increased for decreasing inflation by one unit. As observed in previous chapters, it appears that due to the negative effect of inflation on growth, any attempt to lower the CRR (which, would lead to an excess increase in money supply and hence, an increase in inflation) in the hope of increasing output may also result in a fall in output because of an increase in inflation. Therefore, the net effect on output growth may be lower than expected. This can be clarified as follows. Suppose, during its mid-term review, the bank perceives output is likely to be less than previously anticipated, creating a need to increase credit. This means increasing the broader money supply either by either decreasing the CRR or increasing base money. Suppose the bank decides to lower the CRR? This will raise the monetary aggregate and that will cause inflation creating a trade off for the policy stance. However, as has been demonstrated earlier, any increase in inflation would also reduce output, as is the case in India. Therefore, the net effect on output is ambiguous.

The coefficients of exchange rate change are significant only when a lagged term is included. This shows a disparate attempt by the central bank to arrest continuous depreciation of the currency by increasing CRR.

In the case of CGS1, the significant variables are exchange rate change and the lagged value of the interest rate. Therefore, to control a sliding currency, the monetary authorities appear to use both the interest rate, CGS1 as well as the CRR. However, this does not reflect the trading activity of the central bank in foreign currency. In this regard, it can be noted that India achieved article VIII status of the IMF in 1993. Therefore, most of the effects might be captured from the post 1993 period.

The money market rate, CMR, also appear tailored to the policy stances regarding CRR and CGS1. However, the response of CMR to exchange rate movement is contemporaneous and does not appear to have been based on past trends. This shows it to be a faster instrument in response than either Treasury bill rates or CRR.

The average values of CGS1, CMR and CRR for the sample period are 8.8 percent, 9.96 percent and 9.04 percent, respectively, while the average values of Δp, Δy and $\Delta reer$ are 0.082, 0.046, and –0.0395, respectively. Based on this information, it can be assumed the central bank could target real output growth of about 5 percent and a currency appreciation of about –4 percent. Then, using the formula, $\Delta p^* = (\overline{X} - \beta - \alpha 2\Delta y^* - (\alpha 3 + \alpha 4)\Delta reer^*) / \alpha 1$, the implied target for inflation could be calculated for all three cases. With CRR, the value of target inflation comes out at 0.061, while with CGS1 and CMR it comes out as 0.063 and 0.077, respectively. From these values, the relative importance of the concern for inflation in adopting a particular policy stance is quite evident. The CRR and CGS1 policy stance is taken at a lower inflation rate compared to CMR.

8.2.2 Policy Reaction Function in an Error Correction Framework

With insignificant β in the above non-linear estimation, it can be inferred that the changes in the policy variables are not motivated by any bliss points of output growth, inflation or the exchange rate. This appears to be consistent for a developing country, where the equilibrium output and corresponding inflation or exchange rate are not achieved. Therefore, an alternative strategy of estimating policy could shed more light on the policy stances of the RBI i.e. some kind of long-term policy with respect to output and inflation along with short-term adjustments in policy variables. This kind of reaction function for the central bank can be modeled in an error correction specification. In view of the fact that the variables of interest are not integrated of the same order, the general to specific method of single equation restricted error correction modeling discussed in Chapter 4 (see equation 4.17) has been used to model CRR, CGS1 and CMR. It is an exercise of specification search and only those variables found relevant in specifying the model are retained. Therefore, this exercise also provides a search for the behaviour of the central bank. The estimated models are presented in Table 8.2 and the plots of the fitted values and the regression residuals are presented in Figures 8.4 to 8.7. All three models have satisfactory statistical properties.

The cumulative sum (CUSUM) of recursive errors and CUSUM of the square of recursive errors (not reported) are also within 5 percent significance level for CRR and CGS1, indicating there is no structural break. However, in the case of CMR, the CUSUM of squares shows a mild problem of structural break between the periods of 1988-92. The equations are tested for non-linear effects of inflation and no such evidence is found.

The results presented in Table 8.2 provide strong support for some of the earlier conclusions and also shed more light on the priorities of policy makers. For example, in the long run as well as in the short run all policy instruments seem to be directed towards controlling inflation. CRR policy is also significantly explained by short-run and long run movements in output growth and real exchange rate depreciation. The CGS1 policy seems to have long run concern for the level of output instead of output growth in addition to inflation and currency depreciation.

From Figure 8.4, it is clear that during the late seventies and early eighties there were either smaller or no movements in the CRR and the central bank did not use it actively, whereas, after the late eighties, there is more variation in the CRR. Particularly, the CRR is being reduced. With policy being given more orientation towards interest rate instruments, reduction in the CRR may be under active consideration by the RBI. This is also evident from recent movements in the interest rate, which was almost static during the earlier periods (see Figure 8.5).

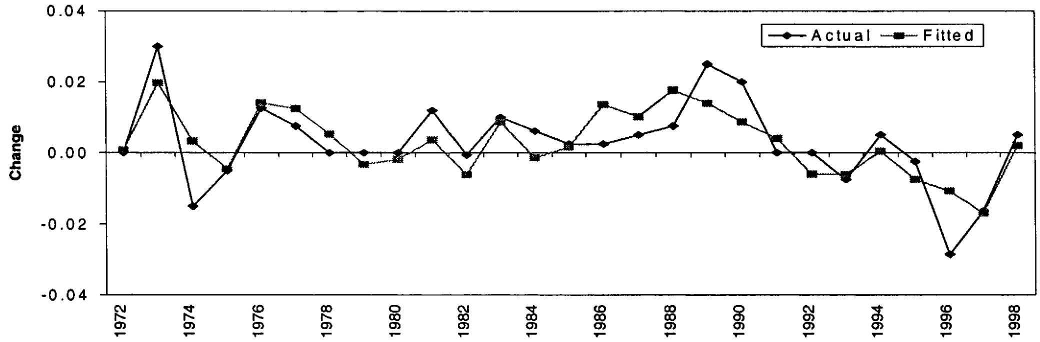
The policy stances on interest rates are also intuitive. It is clear from Figures 8.5 and 8.6 that, during the 1970s and early 1980s, there were smaller movements in the CGS1 and CMR and the central bank did not actively use interest rates, whereas, after the late eighties, there is more variation in interest rates. Therefore, most of the explanatory power for these models is derived from the later years of bank activities. With respect to inflation, exchange rate depreciation and output, the long term and short-term stances are as expected. It can be mentioned that the real exchange rate has a depreciating tendency, which may not be considered conducive to the health of an economy. Therefore, all three instruments are applied to support the currency.

Table 8.2 Error correction models of policy instruments

Dependent Variable	ΔCRR (Change in cash reserve ratio)	ΔCGS1 (Change in yield on 1-5 year government security)	ΔCMR (Change in call money rate)
Regressors	1972-98	1973-98	1972-98
INTERCEPT	-0.0136 (0.0.01)	-1.063 (0.275)*	-0.018 (0.018)
CRR (-1)	-0.238 (0.0611)*		
CGS1 (-1)		-1.116 (0.227)*	
CMR (-1)			-0.915 (0.147)*
Δp (-1)	0.144 (0.065)**	0.565 (0.129)*	0.532 (0.124)*
y (-1)		0.068 (0.018)*	
Δy (-1)	0.415 (0.135)*	0.340 (0.139)*	
Δy (-2)		0.220 (0.101)**	0.354 (0.157)**
$\Delta reer$ (-1)	-0.160 (0.044)*	-0.405 (0.090)*	
$\Delta reer$ (-2)		-0.116 (0.050)**	
$\Delta(\Delta p)$	0.218 (0.062)*	0.206 (0.071)*	0.349 (0.102)*
$\Delta(\Delta y)$	0.302 (0.087)*		
$\Delta reer$			-0.294 (0.077)*
$\Delta(\Delta reer)$	-0.097 (0.034)*	-0.146 (0.047)*	
ΔCGS1 (-1)		0.566 (0.183)*	
DRAIN		0.064 (0.03)**	
DRAIN(-1)			0.145 (0.037)*
R-Square	0.58	0.72	0.76
R-Bar-Square	0.42	0.50	0.68
S.E of Regression	0.099	0.012	0.021
F-statistics F (k-1, n-k)	3.68 [0.01]	3.23 [0.02]	9.93 [0.00]
Diagnostic Tests			
DW-statistics	2.15		2.28
DW-h-statistics		-1.39 [0.16]	
LM (1) serial correlation	0.22 [0.64]	0.60 [0.44]	1.18 [0.18]
LM (3) serial correlation	0.43 [0.93]	3.01 [0.39]	6.55 [0.09]
ARCH (3) test	1.77 [0.62]	5.50 [0.14]	5.20 [0.16]
Functional Form CHSQ (1)	0.10 [0.78]	0.05 [0.82]	0.28 [0.60]
Normality CHSQ (2)	2.44 [0.29]	0.93 [0.63]	0.33 [0.85]
Predictive failure CHSQ (6)	5.57 [0.47]	4.78 [0.57]	
Residual Unit root test			
Test statistics (DF)	-5.17	-5.40	-5.57

Notes: Predictive failure test is conducted by breaking the sample at 1992. Unit root test statistics are presented corresponding to the SBC model selection criteria in an unit root test with second order ADF; *significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values. In F-statistics k is number of regressors including intercept and n is the number of observations.

Figure 8.4 Actual and fitted values of change in CRR (1972-98)



Plot of residuals of change in CMR and two standard error bands (1972-98)

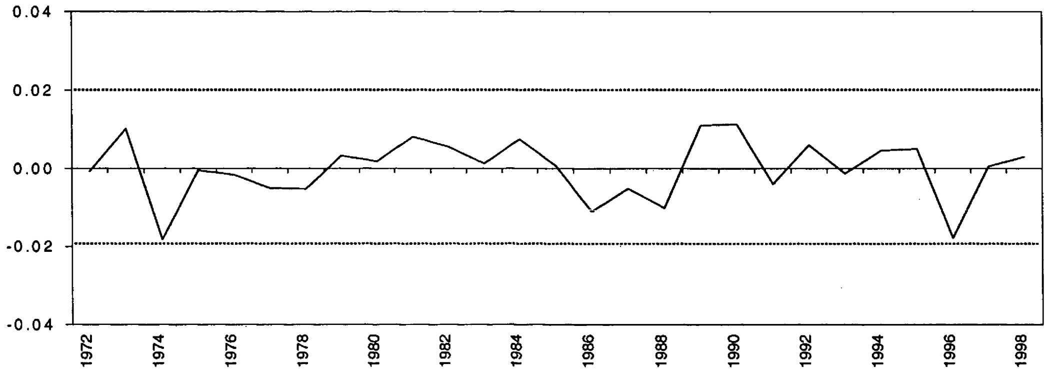
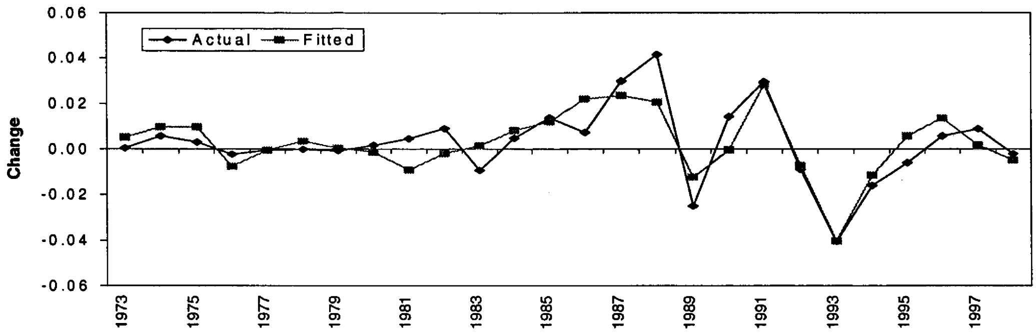
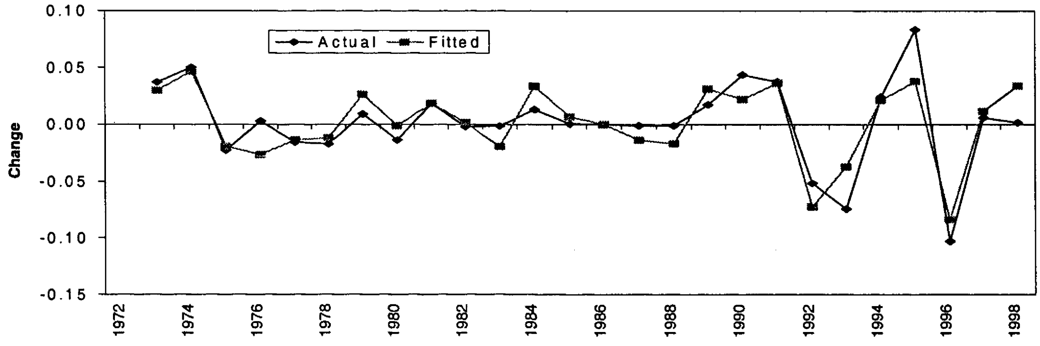


Figure 8.5 Actual and fitted values of change in CGS1 (1973-98)

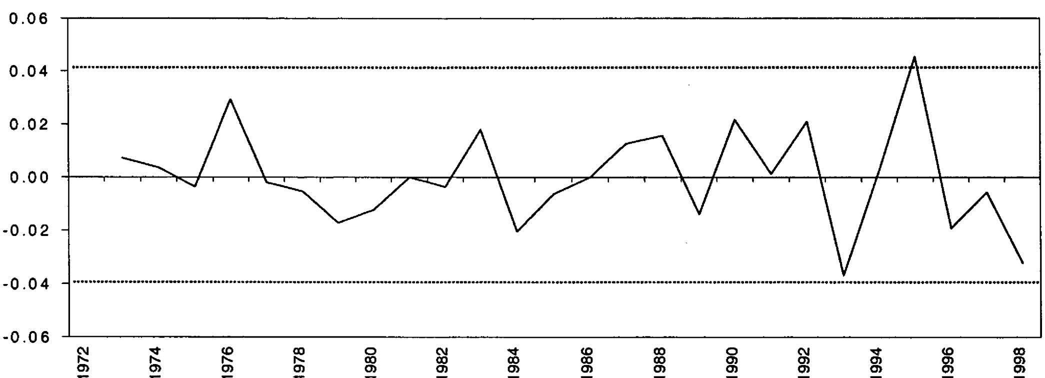


Plot of residuals of change in CGS1and two standard error bands (1973-98)

Figure 8.6 Actual and fitted values of change in CMR (1972-98)



Plot of residuals of change in CMR and two standard error bands (1972-98)



Variation of monsoon season rainfall from the normal (DRAIN) taken as a fraction is also used to model interest rates and found to be significant. On occasions, the RBI takes a forecast about likely agricultural output from rain conditions. When rain is better than normal (negative DRAIN), the RBI tends to increase interest rates, probably in fear of increased inflation. However, this is not appropriate policy for a supply side dominated economy with a steep aggregate demand curve as discussed in Chapter 5, where it is argued that with a favourable supply shock demand side stimulus will be better strategy. However, a positive sign of DRAIN also means the RBI reduces interest rate with adverse rainfall with an idea of boosting industrial output and compensating for the expected fall in agricultural output, which can be inflationary.

8.3 EFFECTIVENESS OF POLICY VARIABLES: AN EVALUATION

The reaction functions estimated above demonstrate the intent of the RBI. However, it is not clear from the foregoing analysis, whether the policy stance taken at time zero effectively performed its job in subsequent periods. More specifically, the questions, such as did an increase in CRR cause future inflation to fall or exchange rate to appreciate, are not addressed.

This section examines the behaviour of the instruments available to the RBI in respect of their effects on the goal variables of output growth, inflation and the exchange rate change. As mentioned earlier, the RBI has used both quantity and price controls to implement its policies, with CRR considered to be a powerful quantity control instrument. As decided earlier, the price control instruments considered for examination are the yield on 1-5 year government securities (CGS1), which proxy the opportunity cost of base money, and the overnight inter-bank call rates (CMR) of commercial banks. It is important to know how these instruments affect future output growth, inflation and the exchange rate. In other words, the question to be addressed here is which instrument is most important for each of the goal variables.

Future outcomes are considered either as the result of policy stances taken in the past, or the current period in anticipation of the likely movements in the goal variables. It is not evident from the RBI publications that they work with published targets for inflation, output or the exchange rate. However, some reference is made to the money supply growth (also see discussion in Chapter 1). Therefore, it is not claimed here that the tests conducted below represent the exact behaviour of the RBI *per-se* with respect to targets. Instead, the objective is to discover what the policy stances taken in period zero have done to the variables of interest from period one onwards. For this purpose Granger causality test is considered useful in shedding light on what happens to the goal variables when an instrument is increased or decreased. The test is applied in a VAR setup using ex-post realized values of the variables. In a related context, Bernanke and Mihov (1997) have applied the idea of the Granger causality test on monthly data in a VAR setup to discover whether the central bank of Germany (Bundesbank) has been targeting money growth or inflation. For that they attempted to see whether the instruments have caused twelve months ahead forecasted inflation or money growth and concluded that targets of money were missed in favour of meeting the requirements of lower inflation.

In order to implement the Granger non-causality test in the present context, a six variable VAR of order one is used to obtain the equations of the goal variables in terms of lagged values of instrument variables of CRR, CGS1 and CMR and goal variables of output growth, inflation and real exchange rate change. The order of the VAR for this test is selected based on the SBC model selection criteria. The OLS equations of the goal variables are used to test whether lagged values of the instruments are significantly different from zero or not. If lagged value of an instrument is found not to assist in explaining the variables of interest, it can be concluded that it did not cause the goal variable. The results of this test are presented in Table 8.3. Since VAR includes two I(1) variables, statistical properties of the estimated equations including tests for serial correlation, functional form, normality and unit root in residuals is also presented in order to guard against spurious regression.

The results presented in Table 8.3 suggest policy instruments do not have any effect on output growth. However, there is significant effect from call money rates in reducing inflation but at the same time causing currency depreciation. Indicated from this result, inflation is probably more responsive to the call money rate than the nominal exchange rate. It can also be argued that with uncovered interest rate parity a high interest rate causes the spot exchange rate to appreciate and the expected exchange rate to depreciate. It is likely that the latter effect shows up in annual data but not the immediate effect. Further, a high call money rate indicates liquidity constraint of the banks. Therefore, these effects can also be attributed to the conditions of reserve money an issue that will be discussed later.

The CRR is significant (at 10 percent level) in affecting the exchange rate. An increase in CRR results in appreciation of currency, an outcome that is normally expected. Yield on the government security (CGS1) does not appear to significantly affect any of the variables of interest. However, lagged CGS1 was significantly positive (result not shown) in the equation of CRR (but not vice versa), which means some of the effects of changes in the yield in government security might be reflected through effects of CRR. The overall significance of the three instruments can be seen from the Granger block non-causality test (see Chapter 4 for details of the test). Table 8.4 presents the statistics for testing that the coefficients of the instrument variables are zero in the equation for all other variables in the above six variable VAR.

Table 8.3 Test results: policy instrument variable Granger causes dependent variables in OLS equation from a six variable VAR (1972-98)

Instrument variable Granger cause the dependent variable	Equation dependent variable (goal variables of interest)		
	$\Delta reer$	Δp	Δy
Cash reserve ratio CRR (-1)	+ 1.35 [0.083]	+ 0.72 [0.170]	+ 0.04 [0.902]
Yield on 1-5 year security CGS1 (-1)	- 1.18 [0.115]	- 0.26 [0.604]	+ 0.24 [0.485]
Call money rate CMR (-1)	- 1.14 [0.036]	- 0.99 [0.007]	+ 0.14 [0.563]
Equation Properties			
R-Square	0.32	0.42	0.26
R-Bar-Square	0.12	0.25	0.04
LM (1) serial correlation	0.17 [0.68]	1.71 [0.19]	0.02 [0.89]
LM (3) serial correlation	1.27 [0.74]	2.51 [0.47]	3.15 [0.37]
Functional Form CHSQ (1)	1.45 [0.23]	0.04 [0.85]	1.62 [0.20]
Normality CHSQ (2)	0.21 [0.90]	1.49 [0.47]	5.01 [0.08]
Heteroscedasticity CHQ (1)	0.56 [0.46]	1.32 [0.25]	1.37 [0.24]
ARCH (3) test	7.57 [0.06]	4.49 [0.21]	1.19 [0.76]
Unit root test for residuals (DF)	-4.87	-7.13	-5.09

Notes: For the sake of clarity in presentation of the results, coefficients of the variables being tested for causality only are presented. VAR system includes an intercept. Values in square brackets [] are P-values. P-values presented besides the estimated coefficients of the instruments correspond to the Wald test statistics of significance of the instrument variables in the OLS equation of the dependent variable, taken from the 6-variables VAR of order 1. Unit root test statistics are presented corresponding to the SBC model selection criteria in a unit root test with second order ADF. Critical value for the unit root test at 5 percent significance level is –2.99.

Table 8.4 Test results: block Granger non-causality of policy instrument variables in a six variable VAR (1972-98)

CRR	CGS1	CMR
9.62[0.087]	14.36 [0.013]	18.35 [0.003]

Notes: Values in square brackets [] are P-values, which correspond to the CHSQ (5) Wald test statistics of significance of the instrument variables in the equation of all other 5 variables in the 6-variables VAR of order 1. VAR system includes an intercept.

The results in Table 8.4 suggest that the instrument variables have significant interaction in the system though their effects are not all as expected and significant. The loss of effectiveness of the instruments, particularly CRR and the CGS1, with respect to inflation and output growth need some explanation.

As seen in the earlier chapters, inflation in India is a phenomenon affected both from the supply as well as the demand side, which reduces the direct role of the demand side instrument. In addition, the discussion in Chapter 1 on the style of conducting monetary policy in the RBI suggests the possibility of losing coordination in the application of different instruments and the process of money creation. It was pointed out that the RBI does not work through a money multiplier but there is some target for broad money growth calculated using income elasticity and at the same time considerations for creating base money are dependent on fiscal conditions, and foreign reserve position, an entirely different set of considerations (see Vasudevan (1999), and Reddy (1999d). Besides, CRR is used to moderate the liquidity for credit creation. In such a situation, it is hard to know the stock of broader aggregates unless there is a behavioural model to forecast multipliers as estimated in Chapter 7.

In addition, an analysis of the data on the different components of monetary aggregates shows the commercial banks have more liquidity than required by the CRR (see CLR in Table 6.1, Chapter 6), which also works in the direction of weakening the policy stances with respect to the CRR.

As demonstrated earlier, there is no evidence of the RBI targeting the real interest rate; the interest rate has a history of administrative control and does not fully represent the behaviour of the private sector. In the absence of fully market related interaction between the interest rate and the money stock it is possible the effect of interest rate instrument on inflation and output growth is neutralized or even dominated by effects of such actions on base money as motivated from the fiscal deficit and movements in foreign exchange reserves.

Similarly, nominal exchange rate appreciation, in the presence of capital control as is the case in India, may be more on account of movements in the current account and flows in foreign exchange reserves rather than changes in the interest rate. Nevertheless, monetary policy can affect the real exchange rate through inflation. For example, a base money expansion (or a fall in CRR) may cause both inflation and depreciation of the nominal exchange rate. With a dominant inflation effect, the real exchange rate will appreciate and adversely affect exports. However, the resulting deterioration in current account may in turn cause nominal depreciation. With an overshooting exchange rate effect, the real exchange rate may depreciate improving the current account, which in turn appreciates the nominal exchange rate. Therefore, knowledge of the responsiveness of the nominal exchange rate to the monetary expansion and current account position is also important. If nominal exchange rate appreciation is more affected from current account positions, then the role of monetary policy in controlling the exchange rate is limited compared to other policies oriented to improve the current account. However, in the short-run, monetary authorities can influence nominal exchange rate appreciation through the process of sterilization.

In order to make above the point more transparent issues related to monetary actions with respect to reserve money and the instruments and the role of current account in nominal exchange rate depreciation are discussed below.

Parallel Stance on Base Money

A correlation matrix between the policy instruments and the reserve money (M0) presented in Table 8.5 shows a high positive correlation between CRR and m0, CGS1 and m0, and CRR and CMR. It may be noted that the call money rate, CMR is more about the liquidity constraints of commercial banks and depends upon the CRR and reserve money in the system. Whenever policy instruments are raised, action on the reserve money either accompanies or follows. If that is true the instrument should be able to significantly explain base money stock.

Table 8.5 Correlation matrixes of policy instruments and reserve money (1971-98)

	CRR	CMR	CGS1	m0	ΔCRR	ΔCMR	ΔCGS1	Δm0
CRR	1							
CMR	0.59	1						
CGS1	0.88	0.57	1					
m0	0.89	0.36	0.80	1				
ΔCRR	0.02	0.11	-0.03	-0.22	1			
ΔCMR	0.04	0.51	-0.04	-0.08	0.45	1		
ΔCGS1	-0.13	0.21	0.16	-0.09	-0.05	0.22	1	
Δm0	0.16	-0.12	0.03	0.08	0.48	0.11	-0.33	1

Base money is a highly trended variable, while instruments are not expected to follow trend. Therefore, the relationship between base money supply and the policy stances with respect to the chosen instrument variables can be better analyzed in the presence of a trend variable that is around a trend growth path of base money. Trend is expected to proxy observed and un-observed supply side variables other than the policy instruments. The resulting estimated equation is presented in Table 8.6 and the following inferences can be made from this estimation.

First, the coefficient of CRR and CGS1 are statistically significant with positive sign. Therefore, this estimate can be dubbed the parallel reaction of the central bank to its own previous actions on the instruments. An increase in base money follows an increase in CRR or the yield on the government security. Importantly, the motivation for such actions may be entirely different (such as fiscal deficit) from the motivations for increasing the policy instruments (such as currency depreciation or inflation). It may be recalled from Chapter 5 that contemporaneous money growth causes inflation, which is neutralizing past actions on the CRR and CGS1.

Second, the coefficient of CRR is high positive value, which means that increases in base money following each percentage point increase in CRR would offset the effects of CRR on the multiplier. The average CRR and currency with the public as percentage of deposits during the sample period were 0.09 and 0.33, respectively (see Table 6.1, Chapter 6), which together yield a multiplication factor of 2.38, a quantity smaller than 2.72, the coefficient of CRR in Table 8.6. Therefore, the actions of the RBI is such that the broader aggregates grow more on account of actions on base money with a neutralizing effect on CRR stance.

Table 8.6 Policy instruments as explanatory variables for reserve money stock (1971-98)

$$m0 = \underset{(0.024)}{10.55^*} + \underset{(0.666)}{2.72}\, CRR(-1)^* - \underset{(0.313)}{1.76}\, CMR(-1)^* + \underset{(0.414)}{0.745}\, CGS1(-1)^{***} + \underset{(0.00)}{0.138}\, T^*$$

R-square = 0.9991, R-bar-square = 0.999. SE of regression = 0.041, DW statistics = 1.90. LM serial correlation CHSQ (3) = 2.58 [0.46]. ARCH (3) CHSQ (3) = 0.33 [0.95]. Functional form RESET CHSQ (1) = 0.586 [0.44]. Normality CHSQ (2) = 0.232 [0.89]. Predictive failure test CHSQ (6) = 10.32 [0.11]. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 5.33.

*significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

The negative sign of coefficient associated with CMR confirms it as an indicator variable and a lower call money rate explains more than required base money supply. However, its negative sign also suggests the monetary authorities do not react to the indications provided by CMR. Probably, this is the reason an increase in CMR explains a fall in inflation with a lag, an argument presented earlier based on the results in Table 8.3.

The cash reserve ratio provides a general framework of monetary policy and variables such as the call money rate are likely to reflect stances taken on the CRR and base money supply. In order to shed light on the response of the call money rate to the changes in the cash reserve ratio and base money, an estimate of the call money rate is presented in Table 8.7. Clearly, a higher CMR indicates higher contemporaneous CRR and/or lower base money. There is a significant long-term relationship between CRR and CMR and between base money and CMR. However, CMR responds more to CRR in the long term than base money. Thus, CMR can provide some indications about base money growth in the short run for a given value of CRR. However, as discussed above, there is no evidence from the results in Table 8.6 and 8.7 that the monetary authorities are using the indications from CMR to take action on base money.

Table 8.7 Call money rate as a function of cash reserve ratio and reserve money stock (1971-98)

$$CMR = \underset{(0.09)}{0.332^{*}} + \underset{(0.27)}{1.280}\ CRR^{*} - \underset{(0.009)}{0.025}\ m0^{*} - \underset{(0.08)}{0.157}\ \Delta m0^{**}$$

R-square = 0.56, R-bar-square = 0.51. SE of regression = 0.024, DW statistics = 1.98. LM serial correlation CHSQ (3) = 2.59 [0.46]. Heteroscedasticity CHQ (1) = 2.45 [0.12]. ARCH (3) CHSQ (3) = 8.97 [0.03]. Functional form RESET CHSQ (1) = 2.13 [0.14]. Normality CHSQ (2) = 0.08 [0.96]. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 5.57.

*significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

Nominal Exchange Rate Behaviour

As argued above monetary policy may have little effect on nominal exchange rate movements compared to other factors such as current account position. In popular discussion, the current account has always been recognized as an important determinant of exchange rate (Dornbusch 1980:239). However, there are several competing theories such as the one in Keynesian tradition, which do not assign any role to the current account. The portfolio balance model of exchange rate determination also suggests the nominal exchange rate is a function of domestic bonds, foreign exchange assets and domestic money held in country (Hallwood and MacDonald 1995: chapter 10). In the absence of free mobility of international capital, it can be argued that the current account being a flow concept, a current account imbalance will have an effect on the stock of assets and thus on the exchange rate over time. Therefore, the current account can be considered an important determinant of nominal exchange rate in a country like India. The average current account deficit in India has been around 1.1 percent of GDP with a coefficient of variation of one.

However, the monetary authority can influence the exchange rate in the short term through trading in foreign exchange and sterilization activities. Draining foreign exchange reserves in order to buy domestic currency would appreciate the nominal exchange rate. In the next step, the central bank buys government securities at a higher price to restore liquidity in the system. This is easy for the RBI as most of the financial institutions that form the major buyers of government security in India are government owned including the commercial banks.

In order to see the role of money, current account and the sterilization process in affecting nominal exchange rate depreciation, a simple model of nominal exchange rate appreciation is estimated in an error correction specification under the assumption that the change in nominal exchange rate has the following reduced form function.

$$\Delta neer = f\,(\text{CAZ}, feru, \text{CGS1}, m0) \tag{8.5}$$

Here $neer$ is the log of nominal exchange rate, CAZ the current account as a fraction of GDP, $feru$ the log of foreign exchange reserves in millions of US$, CGS1 the yield on government securities as described earlier, and $m0$ the log of base money in millions of rupees. A detailed description of data is provided in Annexure 8.1 of this chapter and Appendix AA of this thesis.

The nominal exchange rate change ($\Delta neer$) and all other variables are integrated of order one (see Annexure 8.1 of this chapter). A cointegration test in VECM specification as followed in earlier chapters indicates a cointegrating vector of long terms relations between $\Delta neer$ and other variables but no variable except CAZ was found to be significant when the cointegrating vector was normalized with $\Delta neer$. When CAZ is removed from the list of variables, cointegrating vector is not obtained. However, CAZ and $\Delta neer$ are strongly cointegrated and supports a long run relationship between current account and depreciation of the nominal exchange rate in India.

Therefore the specification search for the variables that can explain nominal appreciation is preferred in the tradition of general to specific modeling. Accordingly, a dynamic error correction equation for the nominal exchange rate appreciation ($\Delta neer$) in terms of current account, foreign exchange reserves, base money and yield on government security is carefully estimated, following general to specific modeling and presented in Table 8.8. Variables, found unhelpful in explaining exchange rate change are not included in the reported equation. Thus, base money does not demonstrate any effect on nominal appreciation.

Table 8.8 An error correction model for nominal exchange rate change (1973-98)

$$\Delta(\Delta neer) \underset{}{=} \underset{(0.015)}{0.015} - \underset{(0.152)}{0.802}\,\Delta neer(-1)^{*} + \underset{(1.194)}{5.658}CAZ(-1)^{*} - \underset{(1.196)}{1.837}\,\Delta CAZ(-1) - \underset{(0.829)}{3.745}\,\Delta CAZ(-2)^{*}$$

$$- \underset{(0.040)}{0.091}\,\Delta feru^{**} - \underset{(0.507)}{1.080}\,\Delta CGS1^{**}$$

R-square = 0.81, R-bar-square = 0.75. SE of regression = 0.038, DW statistics = 2.11. F (6.19) = 13.39 [0.00]. LM serial correlation CHSQ (1) = 0.36 [0.55]. LM serial correlation CHSQ (3) = 4.19 [0.24]. Heteroscedasticity CHQ (1) 1.19 [0.28], ARCH (3) CHSQ (3) = 6.86 [0.08]. Functional form RESET CHSQ (1) = 0.54 [0.46]. Normality CHSQ (2) = 0.90 [0.64]. Predictive failure test (Chow's second test) after breaking the sample at 1992 CHSQ (6) = 7.17 [0.31]. Test of stability (Chow test) of regression coefficients after breaking the sample at 1990 CHSQ (7) = 4.80 [0.68]. CUSUM and CUSUM of square errors do not suggest any structural break. Unit root test for the residuals in second order ADF based on SBC model selection criterion = - 5.00.

*significant at 1% level, **significant at 5% level and ***significant at 10% level; values in parenthesis () are standard errors and values in square brackets [] are p-values.

The estimate demonstrates a significant long-term relationship between the current account and nominal exchange rate change. The long-term current account elasticity of nominal depreciation is about 7, suggesting each percentage point GDP increase in the current account will result in nominal appreciation of about seven percentage points in the long run.

Negative signs of the short-term coefficients of foreign exchange reserve and the yield on the government securities suggest sterilization process leading to currency appreciation. The RBI intervenes in the foreign exchange market and sells foreign exchange reserves to support the currency. However, in the next step, the RBI buys government bonds at higher prices and restores the liquidity of the financial institutions. Both actions taking place during the same period, a currency appreciation is associated with a fall in foreign exchange reserves and government bond rate CGS1. If this story were accepted, it would appear that the results corresponding to the stances on CGS1 in Table 8.3 are also consistent as far as real exchange rate change is concerned.

However, it may be noted that this action may not be coordinated with stances on CRR and at the same time this supports the view that monetary policy has a limited role in affecting currency appreciation and cannot provide a long-term solution to currency depreciation in India. What is feared in such operations is that the crucial objective of inflation control may lose track.

Currency stabilization requires a reduction in the current account deficit by improvements in export performance. The Indian economy is not known to be export driven. During the sample period of 1970-71 and 1998-99 the volume of exports moved from 4 to 13 percent of GDP. This is despite the fact that the average depreciation of the real exchange rate and nominal exchange rate during this period was about 4 and 7 percent per annum, respectively, most of which took place in the last fifteen years. Therefore, it is not the exchange rate alone that matters for export performance. Other factors, such as product selection, product quality, production cost, infrastructure for export promotion, and participation of multinational enterprises may be strategically much more important. There is a limited role for monetary policy in these areas. What monetary policy can contribute is stable general inflation at a low level, so that inflation is not an important consideration in the decision-making process of businesses and households.

From this analysis, it can be argued that it appears difficult to work simultaneously with instruments of quantity and price control. It may be suggested that the RBI should shelve the CRR and concentrate more on interest rates for conducting monetary policy, as is the case in developed countries. With an effective interest rate as the main policy instrument, the amount of reserve money would be an outcome of a systematic process. However, it certainly began efforts to develop the interest rate as a main instrument after the process of financial liberalization commenced. Second, the RBI should clearly define its priorities and the instrument application should be directed more towards achieving that particular objective. This thesis suggests the primary objective should be inflation control. Aiming for several objectives and taking policy stances at different fronts erodes the effectiveness of the policy.

8.4 CONCLUSION

The motivation for this chapter is to estimate the behaviour of the RBI with respect to its instruments and goals. It is argued that monetary policy should have the one goal of maintaining inflation stability if not price stability. This argument gives rise to the question of whether monetary authorities have such a policy stance? Therefore, the central theme of this chapter is to ascertain whether the RBI does have a main policy stance of inflation stability. Accordingly, this chapter attempts to identify the reaction function of the RBI and the impact of the RBI's policy stances on major macroeconomic variables and asks whether the RBI has been more concerned with output growth, inflation, or depreciation of the currency. The analysis has been in two parts. First, policy reaction functions are modeled to see how decisions on policy stance respond to the changes in goal variables. Second, the transmission effects of policy stances on goal variables are analyzed using causality tests and simple regression analyses.

The analysis in this chapter sheds light on the way in which the RBI's policy instruments respond and affect the goal variables (inflation, output growth, and real exchange rate change). The RBI has been using these instruments more actively from the late eighties. The estimated reaction functions clearly suggests that all three policy instruments, namely, cash reserve ratio, call money rate and yield on government securities are increased when inflation and output growth rise or the real exchange rate depreciate. With the CRR, the value of the implied inflation target comes out as 0.061, while, with CGS1 and CMR, its value works out as 0.063 and 0.081, respectively. From these values it is evident that the CRR and the CGS1 policy stances are taken at a relatively lower inflation rate compared with CMR.

However, the analysis of the effectiveness of the instruments on the goal variables is not encouraging. None of the policy instruments is found to cause significant changes in output. CRR policy seems to lose effectiveness due to the parallel actions of the RBI in respect to the base money supply. There is no clear evidence to suggest the policy actions are reducing inflation except in the case of the call money rate, which fundamentally seems to be a result of lower base money stock.

There is some evidence to suggest the RBI is involved in controlling exchange rate depreciation through selling foreign exchange reserves in the short run. However, it appears that not much can be done to stabilize the currency unless policy measures are taken to improve the current account.

From this analysis, it can be argued that it is difficult to work simultaneously with instruments of quantity and price control. It may be suggested that the RBI should shelve the CRR and concentrate more on interest rate for conducting monetary policy, as is the case in developed countries. With an effective interest rate as the main policy instrument, the amount of reserve money would be an outcome of a systematic process. Finally, it is suggested that the RBI should clearly define its priorities and the instrument application should be directed more towards achieving that particular objective. This thesis suggests the primary objective should be inflation control.

Annexure 8.1 Summary definition of data used in Chapter 8

Symbol	Variable description and unit of measurement
CAZ	Current account deficit as a fraction of gross domestic product
CGAPZ	Fiscal Deficit: Combined GAP between Total Outlay and Current Revenue (CTO-CCR) as ratio of gross domestic product.
CGS1	Bond rate: Yield on 1-5 Year government of India (GOI) Securities, taken in fraction. Middle point has been taken for the data given in range.
CMR	Overnight annual call money rate of commercial banks, taken in fractions
CRR	Cash Reserve Ratio: derived according to the RBI notifications as fraction of time plus demand deposits. Average of the values prevailing during the year.
FERU	Gross international reserves (includes gold) measured in current US$ millions.
GDP	GDP at market prices at current prices (rupees million)
M0	Base (Reserve) Money (rupees million).
NEER	Nominal Effective Exchange rate of G5 Countries defined such that an increase indicate appreciation
P	Wholesale price index (WPI) of all commodities converted to base 1993-94 = 100
REER	Real Effective Exchange rate of G5 Countries defined such that an increase indicate appreciation
Y	Gross domestic product at constant market prices (rupees millions)

Annexure 8.2: Unit root test for the variables used in Chapter 8 in levels and first differences

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
CAZ	DF	-2.98	-2.96	81.76	80.50	-3.59	-3.41	82.07	80.18
	ADF (1)		-1.85	81.87	79.98		-2.18	81.61	79.09
ΔCAZ	DF	-2.99	-9.50	81.01	79.79	-3.60	-9.61	80.82	78.99
	ADF (1)		-5.78	80.62	78.79		-5.86	80.47	78.03
CGAPZ	DF	-2.980	-1.47	81.63	80.37	-3.594	-1.80	81.27	79.38
	ADF (1)		-1.18	81.71	79.82		-1.21	80.91	78.40
ΔCGAPZ	DF	-2.985	-7.24	80.43	79.21	-3.603	-7.47	80.42	78.59
	ADF (1)		-3.95	79.43	77.61		-4.23	79.46	77.02
CGS1	DF	-2.980	-1.23	69.22	67.96	-3.594	-1.48	68.69	66.81
	ADF (1)		-1.41	68.94	67.05		-2.00	69.09	66.58
	ADF (2)		-1.15	68.60	66.09		-1.48	68.25	65.10
ΔCGS1	DF	-2.985	-3.98	65.66	64.45	-3.603	-3.92	64.75	62.92
	ADF (1)		-3.95	65.61	63.78		-3.91	64.77	62.33
CRR	DF	-2.980	-1.68	77.54	76.29	-3.594	-0.74	76.54	74.66
	ADF (1)		-1.68	77.03	75.14		-1.37	76.44	73.93
ΔCRR	DF	-2.985	-4.41	76.10	74.88	-3.603	-4.26	75.23	73.40
	ADF (1)		-3.74	75.37	73.54		-3.66	74.57	72.13
CMR	DF	-2.980	-3.67	52.64	51.38	-3.594	-3.52	51.75	49.86
	ADF (1)		-3.84	52.52	50.63		-3.84	52.13	49.62
feru	DF	-2.980	-1.67	-1.24	-2.50	-3.594	-1.90	-1.51	-3.39
	ADF (1)		-1.75	-0.84	-2.72		-2.42	-0.23	-2.74
	ADF (2)		-1.75	-1.70	-4.22		-2.68	-0.43	-3.58
Δ*feru*	DF	-2.985	-3.52	-1.93	-3.15	-3.603	-3.49	-2.81	-4.63
	ADF (1)		-2.60	-2.88	-4.71		-2.59	-3.77	-6.21
m0	DF	-2.98	-0.17	33.69	32.44	-3.59	-2.95	36.86	34.97
	ADF (1)		-0.15	32.71	30.82		-3.41	37.20	34.68
Δm0	DF	-2.99	-4.93	32.06	30.84	-3.60	-4.83	31.08	29.25
	ADF (1)		-4.17	31.64	29.81		-4.09	30.68	28.24
neer	DF	-2.980	1.56	31.69	30.43	-3.954	-1.50	33.10	31.21
	ADF (1)		0.85	32.53	30.65		-1.68	33.99	31.47
	ADF (2)		0.12	32.98	30.46		-2.13	35.02	31.87
Δneer	DF	-2.985	-2.96	31.30	30.08	-3.603	-3.43	31.63	29.80
	ADF (1)		-1.68	32.08	30.25		-1.98	31.70	29.26
	ADF (2)		-1.52	31.08	28.64		-1.87	30.79	27.74
ΔΔneer	DF	-2.991	-9.31	32.14	30.92	-3.612	-9.13	31.27	29.44
	ADF (1)		-4.74	31.29	29.46		-4.67	30.43	27.99
Δp	DF	-2.98	-4.10	38.41	37.19	-3.60	-3.97	37.41	35.58
	ADF (1)		-4.43	39.00	37.17		-4.29	38.01	35.57
reer	DF	-2.98	0.09	29.29	28.03	-3.59	-1.90	30.44	28.56
	ADF (1)		0.00	28.40	26.52		-2.02	29.85	27.34
Δreer	DF	-2.99	-4.44	28.14	26.92	-3.60	-4.37	27.21	25.39
	ADF (1)		-2.91	27.27	25.44		-2.84	26.31	23.87
y	DF	-2.98	1.24	53.29	52.04	-3.59	-2.13	54.93	53.05
	ADF (1)		1.58	52.98	51.09		-1.85	54.22	51.71

Variable	Lag structure	The Dickey-Fuller regressions include an intercept but not a trend.				The Dickey-Fuller regressions include an intercept and a linear trend			
		95% critical value	Statistic	AIC	SBC	95% critical value	Statistic	AIC	SBC
Δy	DF	-2.99	-5.70	50.48	49.26	-3.60	-6.10	50.85	49.02
	ADF (1)		-3.83	49.48	47.65		-4.35	50.18	47.74

Note: ADF = Augmented Dickey Fuller. AIC = Akaike Information Criterion. SBC = Schwarz Bayesian Criterion of model selection. The order of ADF test is chosen as 2 in all the cases. Number of observations varies from 23 to 26.

Chapter 9

Conclusion

This thesis is developed with two sets of objectives, one general and the other specific. The general objective is to understand the processes of monetary policy in theory and practice with a specific reference to the problems of a developing country such as India. In order to achieve the goal of the general objective, some specific objectives in the form of questions were asked in the introduction of the thesis that have their origin in the current debate on the objectives and means of conducting monetary policy in India. This is also an unfinished debate in most other countries. In order to summarize the findings of this study, the objective questions are re-stated and the conclusions follow based on the empirical analysis of the thesis. Annual data for the period 1970-71 to 1989-99 has been used for the empirical analysis.

1. Why should the RBI be concerned with inflation above anything else?
2. How best can the inflationary process in India be identified and modeled? More specifically, to what extent is inflation a monetary phenomenon in India and how much is it a supply side effect? Do all monetary aggregates behave alike or do they have different roles in determining inflation in India?
3. What is the prospect of money demand based monetary policy in India? What determines the money stock, is it money demanded or a reflection of money supply behaviour?
4. How best can the behaviour of the RBI be explained with a policy rule for the existing monetary instruments? Specifically, how best can CRR and interest rates be modeled for India in terms of goal variables and whether such policy stances are effective?

9.1 Need for Inflation Control

Several recent studies based on cross-country, panel, and single country time series regressions and other types of calculations, particularly on tax effects and surveys have shown long-run negative effects of inflation on economic growth. Business and households are thought to perform poorly when inflation is high and unpredictable. It is therefore argued that the expected rate of change of the general level of prices should be so low that it ceases to be a factor in the individual and business decision making process. Thus, there is growing consensus among policymakers that inflation needs to be controlled. It is argued, that central banks should emphasize price stability as the single objective of monetary policy and eschew consideration of other goals such as growth or employment. Although there is unlikely to be a single optimal level of inflation, in several studies on developed countries around two per cent is considered a benchmark of price stability. In the case of a developing country such as India this limit can be higher due to the possible higher incidence of measurement errors, an underdeveloped financial sector, a lower degree of market integration and government intervention of various kinds including populist policies and involvement in the production process.

The analysis in Chapter 4 of this thesis has clearly brought out a negative long-term effect of inflation on economic growth in India, while the analysis in Chapter 5 shows a robust positive effect of money growth on inflation. A long-term negative effect of inflation on growth and a positive effect of excess money growth on inflation also mean non-neutrality of money, but, in this situation, instead of helping, excess money growth is detrimental to economic growth. Therefore, it is pragmatic for monetary policy to concentrate on inflation in preference to anything else.

Analysis in Chapter 4 specifically identifies a robust threshold level of inflation for India at 5½ percent in a well-specified growth model. Every percentage point increase in inflation over 5½ percent causes per capita output growth to fall by about 0.16 percentage points in the long run, which is a significant impact. Incidentally, the average inflation rate in major trading partner countries of India during the sample period of 1971-98 was also in the same range. Thus, historical evidence suggests that India should be careful to prevent inflation from exceeding 5½ percent. The results also show that inflation does not exert any significant indirect effect on economic growth through investment. Further, while the nominal interest rate on lending as well as deposits appears to decrease private investment, the fiscal deficit seems to exert a positive influence on private investment. However, when the result of Chapter 7, which demonstrates fiscal dominance on money creation, is taken into account, via the effect of money growth on inflation and the effects of inflation on growth, it comes out that the combined fiscal deficit of states and the central government should be kept to a level below 6½ percent; the combined gap between outlay and revenue during 1998-99 was about 10 percent of GDP.

Further Inflation is also inequitable because it hits poor people the most. The government can draw some benefits by way of collecting an inflation tax but that may not help the large mass of people in India living below the poverty line. On the contrary, increasing the purchasing power of the rupee by reducing inflation would be of direct help and would provide a more conducive environment for economic activities by reducing social tensions.

9.2 Inflationary Process

The survey of the theory of inflation presented in Chapter 2 has been helpful in understanding of the current literature on inflation and its relevance in the Indian context. The discussion in Chapter 2 supports the point that the mechanism of inflation is far from being a settled issue. Episodes such as the combination of low inflation and low unemployment enjoyed by the United States in the late 1990s questions a short-run trade-off between the two variables. This brings to the forefront the importance of country specific empirical studies. However, it can be argued that money growth captures several sources of inflation, including that transmitted from abroad, and inflation can be influenced by controls on money growth. In economies where financial markets are fully developed, an instrument such as short-term interest rates can find the same role. Nevertheless, wage setting behaviour; supply shocks; and structural rigidities are equally important in modeling inflation. The most appropriate model remains specific to the nature of the economy.

The possibility of supply side inflation accompanied by monetary accommodation is often discussed in economic surveys of the Ministry of Finance, Government of India. The main sources of supply shocks could be oil prices, currency devaluation, flow of foreign currency, weather conditions affecting agricultural prices, productivity improvements, and price competition, together with a changing economic environment due to economic reform. Government interventions in the price setting of administered goods and lump sum increases in wages arising out of periodic adjustment particularly in the public sector also contribute to supply side effects on inflation. Finally, in the absence of transparency and the desire to stimulate the economy to a higher growth path, monetary authorities can always generate inflation of the type of discretionary policy, though this may be with ad hoc decisions instead of model optimization.

While it is complex to decipher the inflationary process in India, an attempt has been made in Chapter 5 to address this problem. This chapter uses the concept of the output gap to identify whether the Indian economy is dominated by demand-side or supply-side factors. The interesting outcome of this chapter is the negative association between inflation and the contemporaneous output gap. With a downward sloping aggregate demand schedule and upward sloping supply schedule, a negative relationship between inflation and the output gap indicates the profound impact of the supply side of the economy. It also shows that the output gap contains important information about the inflationary process in India and both supply and demand side variables are important in understanding this process. The supply side variables that significantly explain variation in output gap are identified as rainfall, mineral and edible oil price inflations, and growth in international reserves.

Using the information content of the output gap, a mark-up price model of inflation with discretionary narrow money growth, wage inflation, oil prices inflation, and growth in international reserves has been developed and evaluated. It shows that such a model performs well in explaining inflation in India and the performance of the model can be enhanced if more information about the output gap can be foreseen. To the basic question of 'can monetary policy affect inflation in India' the answer is clearly 'yes'. However, the role of monetary policy is limited by the presence of significant supply side effects.

There is a clear unidirectional causality running from narrow money growth to inflation in India and not vice-versa. By contrast, base money growth and broad money growth demonstrate bi-directional causality with inflation. Therefore, narrow money growth has been identified as an important causal variable for inflation and systematically introduced in inflation models. To control inflation, the monetary authority should be concerned with the growth rate of narrow money rather than with other aggregates. The long run effect on inflation of a one-percentage point increase in narrow money growth is approximately 0.43 percentage points.

However, narrow money is not an instrument controlled by the central bank; the instrument is base money or the interest rate or cash reserve ratio (CRR). Therefore, the narrow money multiplier is modeled in Chapter 7. It comes out that the narrow money multiplier is significantly explained in an error correction specification by institutional variables such as cash reserve ratio, deposit rate, yield on government securities, call money rate and commercial bank density representing institutional development. Therefore the analysis provides a framework to calculate monetary effects on the inflation process in India.

9.3 Monetary Policy Evaluation

Chapter 3 presents a brief survey of the developments, which have led to the current framework of conducting monetary policy in developed and developing countries. It is noted that financial market volatility has led modern central banks to choose interest rates as the main instrument for conducting monetary policy, and, at the same time, a breakdown of the stable relationship between output and monetary aggregate and the failures of exchange rate pegs has motivated most central banks to adopt an inflation rate as the primary goal of monetary policy. Recently, forecasted inflation has emerged as one of the key intermediate targets for monetary policy because of the argument that it is to be highly correlated with the socially optimal inflation rate, the goal variable.

The RBI conducts monetary policy based on the notion of a stable function of demand for real broad money with income elasticity of about 1.58. Since RBI studies have stressed the stability of real broad money demand, an attempt has been made in Chapter 6 to model and test the robustness of the demand for broad money, (and also narrow and base money) in a variety of long-term specifications such as Orcutt-Cochrane method, partial adjustment and cointegration. The outcome is not encouraging. While income elasticity of about 1.52 is obtained in simple regression of real broad money on output, it fails miserably in robustness tests. When real broad money is specified as a standard demand equation, output, the key variable is not at all robust to the inclusion of other relevant variables such as, inflation, interest rate, and trend. The examination of the base money demand also meets the same outcome.

Therefore, it is concluded that the money-output relationship in India is very loose and any attempt to conduct monetary policy based on the paradigm of a stable demand for money is more likely to fail than succeed. As discussed earlier, the loosening of the relationship between money and output may be due to the operation of Goodhart's law. Discretionary supply of money due to various reasons, such as a fiscal deficit, directed credit, and interventions in the foreign exchange market, must have helped in loosening the money-output relationship.

There is evidence to suggest that demand for narrow money is better defined but it does not really assist, because narrow money by definition neither represents the base money where the central bank has better control nor all the institutional categories of money. Therefore, conducting monetary policy based on narrow money could be a temporary arrangement at best until the interest rate becomes the major instrument of monetary policy.

Most studies on monetary aggregates in India are based on the assumption that there is no public money illusion. However, simple regression analyses in Chapter 6 reveal this assumption is not robust. Demand for money does not imply demand for real money. Price level should be treated as a separate variable while modeling nominal or real money.

The motivation for Chapter 7 is drawn from the findings of Chapter 6, which conclude that the money-output relationship in the demand for money specification in India is very loose. In Chapter 7, the supply behaviour of all three monetary aggregates has been analyzed from the perspective of the possibility of control on their growth. The narrow and broad money multipliers both appear to be endogenous to institutional variables. The models of multipliers are well specified and it is possible to control money growth through policy instruments and institutional developments. However, the critical problem arises due to endogeniety of base money growth itself. When the base money equation is specified like a supply equation, by including the fiscal deficit as an explanatory variable, it demonstrates good stability and predictive power. Permanent income obtained by error learning hypothesis comes out to be a better scale variable for explaining the supply behaviour of base money. The fiscal deficit is introduced in two alternative specifications: in one the external effect is represented by real exchange rate and interest rate, while in the other the external effect is represented with foreign exchange reserves. In both specifications the long run money supply increases with fiscal deficit and income. There is pressure on money creation from foreign exchange flows, which makes monetary control harder.

The short-run response to the fiscal deficit is found to be decreasing, following gradual abolition of automatic monetization and it can be argued that fiscal dominance is beginning to reduce. The above results have important implications in terms of possibilities for monetary policy. Inflation control requires a lower growth rate for narrow money and at the same time financial deepening requires a high multiplier. Both together require that the base money growth must be controlled, which seems a daunting task in the presence of a high fiscal deficit.

The base money supply equation appears to indicate passive behaviour and there is no evidence of short run reaction to output growth and inflation. There is some evidence of a short-run reaction to exchange rate appreciation but in the long run currency depreciation is also accommodated. With fiscal dominance and anticipated inflation there is evidence to suggest the RBI is conducting open market operation in government securities to counter inflationary expectations rather than to maintain a nominal interest rate. In the long-run inflation is not accommodated fully.

Therefore, it is important to examine the reaction functions of the direct instruments such as CRR and indirect instruments such as interest rates. Chapter 8 examines the RBI's policy stances with respect to such instruments, where consequences of passive supply of base money on the effectiveness of the policy stances with respect to instruments is also examined.

The main instrument for conducting monetary policy in India has been the cash reserves ratio (CRR). While interest rate instruments are also available but have not been fully market determined, as in the developed countries and are therefore expected to be comparatively less effective. Following an examination of the different interest rate series available in India, the yield on 1-5 years Central Government Securities (CGS1) and the overnight inter-bank call money rate (CMR) have been selected along with the CRR in order to analyze the RBI policy stances in Chapter 8. The analysis has been done in two parts. First, policy reaction functions are modeled to see how decisions on policy stance respond to the changes in goal variables. Second, the transmission effects of policy stances on goal variables are analyzed using causality tests and simple regression analyses.

The analysis in this chapter sheds light on the way in which the RBI's policy instruments respond and affect the variables of interest. It is of interest that the RBI has used these instruments more actively from the late eighties, particularly following the commencement of liberalization in mid of 1991. With the CRR, the value of the implied inflation target comes out as 0.061, while, with CGS1 and CMR, its value works out as 0.063 and 0.081, respectively. From these values, the relative importance of the concern for inflation in adopting a particular policy stance is quite evident. The CRR and CGS1 policy stances are taken at a relatively lower inflation rate compared with CMR. A significant long run relationship between output and interest rate variables in ECM suggests the central bank takes into consideration the long-term effects of interest rates on output when deciding on these instruments.

The estimated reaction functions clearly suggests that all three policy instruments, namely, cash reserve ratio, call money rate and yield on government security are increased when inflation and output rise or the real exchange rate depreciates. Rainfall conditions are also taken into account when taking decisions on these instruments. However, the analysis of the effectiveness of the instruments on the goal variables is not encouraging. None of the policy instruments is found to cause significant changes in output. CRR policy seems to lose effectiveness due to the parallel actions of the RBI in respect to the base money supply. There is no clear evidence to suggest the policy actions are reducing inflation except in the case of the call money rate, which fundamentally seems to be a result of lower base money stock.

There is some evidence to suggest the RBI is involved in controlling exchange rate depreciation through selling foreign exchange reserves in the short run. However, it appears not much can be done to stabilize the currency unless policy measures are taken to improve the current account.

The analysis in Chapter 8 provides strength to the argument that it is difficult to work simultaneously with instruments of quantity and price control. It may be suggested that the RBI should shelve the CRR and concentrate more on price variables for conducting monetary policy, as is the case in developed countries. With an effective interest rate as the main policy instrument, the amount of reserve money would be an outcome of a systematic process. Finally, it is suggested that the RBI should clearly define low inflation as its main priority and the instrument application should be directed more towards achieving this particular objective. Aiming for several objectives and taking policy stances at different fronts erodes the effectiveness of the policy.

9.4 Prospects of Inflation Targeting

From the discussion in Chapter 3, it is evident that among the different monetary regimes inflation targeting on the one hand requires relatively more discipline in terms of fiscal management and central bank independence while on the other hand it requires greater financial depth and sophistication in manipulation of instruments. Developing countries, such as India, find it hard to qualify on these accounts. With the combined fiscal deficit of Central and State Governments during 1990s remaining in the range of 8-10 percent of gross domestic product (GDP), more than 25 percent of the time and demand liability of the banking sector held in government securities as SLR and the ratio of gross to net borrowing of the government resting at 0.67 does not bode well central bank independence in India. Because of the high fiscal deficit the central bank finds it difficult to drastically reduce CRR. In addition, to avoiding interest rates rises in the face of Government borrowing the RBI is constrained to finance it at lower cost.

The analysis in Chapter 7 provides clear and robust evidence of fiscal dominance in base money creation in India in the long run. This erodes the independence of monetary policy and hence limits the role of monetary policy in controlling inflation in India. Therefore, as mentioned in Chapters 1 and 3, one of the key requirements of central bank independence for the success of a strict inflation targeting based monetary regime as practiced in developed countries, is not fully met in the case of India. However, this does not mean the RBI should not adopt inflation as the main goal of monetary policy. In fact, both the RBI and the Central and State Governments of India need to commit to controlling inflation, as the long run effect of fiscal deficit is detrimental to economic growth, which works through the inflation channel. The encouraging result in Chapter 7 is that there appears to be some indication of reduction in short run fiscal dominance during the recent periods of the 1990s as the response to the fiscal deficit is found to be decreasing following gradual abolition of automatic monetization.

Further the reforms are a recent phenomenon in India. Market depth for the short-term instruments of monetary policy and effectiveness of OMO is beginning to develop. There has been no liberalization in the area of directed credit. Commercial banks are required to direct 40 percent of their commercial advances to the priority sector, which consists of agriculture, small-scale industry, small-scale transport operators, artisans etc. At present the percentage of directed credit appears too high and needs to be narrowed down to potentials growth and highly focused areas.

Thus, it may take quite some time before all the pre-requisites of inflation targeting as available in the developed economies are achieved in India. After the financial sector reforms that commenced in 1991 the situation must have improved, particularly with the abolition of automatic monetisation, decontrol of most deposit and lending rates and reduction in quantitative controls since 1997. Therefore, it does not prevent the monetary authorities in India from commencing the process of inflation targeting.

Moreover, chapter 5 found a lagged output gap had a positive effect on inflation, which indicated the existence of an upward sloping short run Phillips curve, but that relationship failed with the inclusion of important variables describing the inflation process. In absence of any clear short run trade off between inflation and output, there should be no dilemma for the central bank in setting priorities. Keeping inflation at a low level should be the primary target for monetary policy in India, which can best be achieved by adopting a monetary regime such as inflation targeting.

The spirit of the monetary regime directed towards inflation control need not necessarily be the exact form of inflation targeting practiced in developed countries. The most important thing is to understand the behaviour of the economy and develop an inflation model based on the maximum available information and then to work with model improvements as time passes. The objective of this thesis has the same spirit.

Appendices

AA: Data Sources and Variable Definition

AA.1 A GENERAL NOTE ON DATA

The official data in India is published mainly in two frequencies, monthly and annual. However, data related to several important macroeconomic variables *inter-alia* gross domestic product, investment, savings, and employment are not available in monthly frequency. The output data available in monthly series is the usual industrial production index (IPI), which is considered highly volatile. Further, industrial production in India which accounts for just around a quarter of a share in the total value addition in the economy, can at best be a poor proxy to the real activity. The quarterly series on output commenced only in 1996, which is a very short period and cannot be used for the present analysis.

In the literature on monetary economics and monetary policy analysis in developed countries, data on all three frequencies have been extensively used depending upon the nature of the analysis. For the VAR analysis monthly data has been widely used probably because the contemporaneous correlation between monthly data is expected to be zero and at the same time monthly data provide much longer time series. Further, variables like short-term interest rates and exchange rates interact with a very short lag captured by the monthly data. However, due to the presence of volatility in monthly data on output and prices, several studies prefer quarterly data.

In the absence of quarterly data the natural substitute is the annual data. The main problem with using annual data for the analysis is the contemporaneous relationship between the variables. During a year the variables are able to interact and feed to each other and therefore constructing a lag structure for the variables poses a problem. The short-term in annual data is at best one year and most of the transmission effects are completed within two years. Therefore, policy instances during the year cannot be deciphered. Nevertheless, results based on annual data are expected to be more robust than those based on monthly data because of the reduced volatility of the former.

In the light of such problems, it is proposed in this study to analyze Indian monetary policy using annual data which will be more helpful in analyzing the behavioural aspects of the Indian economy.

Most of the official annual data available on India is for the financial year, which starts on April 1 and ends on March 31. For example, year 1990-91 means April 1990 to March 1991. For the sake of convenience, the financial year 1990-91 is written as 1990, for which most months are covered. The same convention is followed in World Development Indicators (WDI) of The World Bank. As far as possible this convention is maintained. While converting the monthly data into annual data also the same convention is followed. Unless otherwise stated all aggregates are measured in millions (mn) of rupees. However, the foreign currency reserve is measured in millions of US Dollars. Wherever applicable, the annual data is converted to the base period of 1993-94 following the practice in WDI 2000.

Sources of data for this study are discussed in section AA.2 and listed in Table AA.1. Some of the variables, such as Capital Stock, effective exchange rate, international prices and international interest rates are constructed in section AA.3.

Table AA.2 presents the list of variables along with their description and sources. Basic data (untransformed) used for regression analysis is presented in Table AA.3.

AA.2 SOURCES OF DATA

The major sources of macroeconomic data on India are: the Central Statistical Organization (CSO) in the Ministry of Statistics and Programme Implementation; the Economic Survey (ES), which is an annual document published before the budget presentation by the Ministry of Finance; and the Reserve Bank of India (RBI) documents which compile data from various sources including its own departments. Other sources are organizations like the Center for Monitoring Indian Economy (CMIE) and the National Council of Applied Economic Research (NCAER). Important international institutions like The World Bank and the International Monetary Fund also compile Indian data supplied by various government organizations in India. The advantage with international institutions is that they provide consistent and coherent series based on the standard definition and same base year.

There are several online international databases which are useful for monthly data and keep updated series taken from the original sources. EconData Pty Ltd. Armadale in Australia is one such organization, which provides online data from the IMF, World Tables and regional databanks like the China Economic Information Center (CEIC). CEIC data on India are also collected from the official sources stated earlier. The Australian National University subscribes to the online facility of EconData for International Financial Statistics and the online CEIC dataset, which has been very useful for this study, particularly in getting the latest data on monthly frequency. The quality of data from the online source is confirmed for reliability by counter checking with the published data in hard copy of the original sources.

There are two series of annual data in Indian Documents, one with 1980-81 as the base year, which has now been discontinued and other with 1993-94 as the base year starts from the same year. The World Bank annual data given in World Development Indicators (WDI) 2000 CDROM for India are all converted to the 1993-94 base year and therefore, has been used as far as possible as the first choice of constant price annual data for the sake of consistency. Data not available in WDI2000 is complemented from Economic Survey, RBI documents, and other sources like CSO, NCAER, and CMIE. Similarly, for monthly data, the base source considered is IFS, where the data is available with the base year of 1995. However, for constructing annual data from the monthly series, all data is converted to 1993-94 as the base year if required. Details of these sources are provided in Table AA.1. Table AA.2 presents the list of variables along with their description and sources. Basic data (untransformed) used for regression analysis is presented in Table AA.3.

AA.3 CONSTRUCTED VARIABLES

AA.3.1 Permanent Income

In the literature, wealth is considered to be the discounted present value of expected future income. With the rate of discounting remaining constant, wealth would vary in the same way as income. Laidler (1985:87) argued, studying the relationship between variations in money and variation in wealth it is not important whether wealth measured directly or as expected value, also called permanent income, is used as proxy for wealth. Laidler suggested the error learning or adaptive expectation hypothesis for modeling expected behaviour from the actual behaviour of the variable under consideration. Representing the variable by X, expectation of the future value of X held in period t by $X_{t+1|t}$ and a positive fraction by λ, the error-learning hypothesis can be written as

$$X_{t+1|t} - X_{t|t-1} = \lambda\,(X_t - X_{t|t-1}) \tag{AA.1}$$

This can be written as follows:

$$X_{t+1|t} = \lambda\, X_t + (1-\lambda\,)X_{t|t-1} \tag{AA.2}$$

By continuous back-substitution, the expected value of X can be written in terms of the realized values of X in the past as follows:

$$X_{t+1|t} = \lambda\, X_t + \lambda\,(1-\lambda\,)X_{t-1} + \lambda\,(1-\lambda\,)^2 X_{t-2} + \ldots.. + \lambda\,(1-\lambda\,)^n X_{t-n} \ldots. \tag{AA.3}$$

With λ = 0.5 and n=10 the sum of the geometric coefficients on X is equal to 0.5 + 0.25 + 0.125 + 0.0625 + 0.03125 + 0.015625 + 0.0078125 + 0.00390625 + 0.001953125 + .000976563 + 0.000488281 = 0.999511719, which is very close to one. If X is some measure of real income then, $X_{t+1|t}$ can be treated as the permanent income for period t. Thus permanent income calculated using this procedure with λ=0.5, has a fifty percent weight for current income while the rest of the fifty percent weight is geometrically distributed in the past ten year period. The simple assumption underlying this procedure is that people take more notice of the recent past than of more distant time while making an assessment of future income. Laidler (1985:88) states that real national income measured by applying this procedure has often been used as a scale variable in demand for money functions. It may be noted that the choice of the value of λ = 0.5 is as arbitrary as any other value could have been. However, with λ = 0.5, the immediate past two years have reasonable weights.

For calculating the permanent income YP for the period 1970-98 in the present study, real gross domestic product at factor cost (RGDPF) for the period 1960-1998 at 1993-94 prices is taken from WDI 2000 as the measure of income and the above relationship is used with λ = 0.5 and n = 10. The expected income for the period t+1 is considered as the permanent income for the period t.

AA.3.2 Net Fixed Capital Stock

The measure of capital K(t) at any time t used for estimating the potential output in this study is the real net fixed capital stock (NFCS), which is obtained by the method of perpetual inventories, considering 1993-94 as the base year, such that t = 0 for 1993-94. A depreciation of 5% is used in the following relationship:

$$K_t = 0.95*(K_{t-1}) + RGDFI_t \text{ for } t > 0, \text{ years beyond 1993-94 and}$$
$$K_t = [K_{1+t} - RGDFI_{1+t}]/0.95 \text{ for } t < 0, \text{ years before 1993-94} \quad \text{(AA.4)}$$

K_0 is the 1993-94 stock of fixed capital at current prices taken from the National Account Statistics 1997, statement 21 published by the CSO (refer document CSO-NAS in Table AA.1) and its value is Rs. 18634480 million. RGDFI is the real gross fixed investment at 1993-94 prices taken from WDI 2000.

AA.3.3 International Variables

An attempt is made in this section to find the proxy price, output, and exchange rate for the rest of the world with respect to India. These variables are first generated at monthly frequency and then converted to annual frequency, by taking averages of the monthly values. It is assumed that the international economy for India can be represented by a group of five-countries (G5), namely the United States of America, Japan, the United Kingdom, Germany and France. During 1990-91 – 1998-99, together these five countries constitute an average 40 percent of exports and 31 percent of imports resulting in 36 percent of India's trade with the rest of the world. The Indian monetary authorities closely monitor the movement of currencies and monetary stances of these countries. The changes in output, prices and exchange rate in these countries are expected to have more effects on the Indian economy than other countries.

Trade being the main channel of transmission for the effects of changes in prices and output from one country to the other, it is found appropriate to use trade based weight for creating composite indices of consumer price index (CPIG5), producer price index (WPIG5) and an industrial production index (IPIG5) for G5 countries to proxy international prices and industrial production index (IPI). The trade weight is the relative share of each of the G5 countries in their combined bilateral trade volumes with India.

Trade weights are also used for calculating the effective exchange rate (EER). The assumption here is that the international dollar equivalent of the demand and supply of the domestic currency is largely affected through trade activities, particularly when the exchange rate is market determined and free floating[85]. The problem is simplified by taking the same composite bilateral trade (export + import)[86] weights for all three variables under discussion. While several countries use fixed weights to arrive at the EER or trade competitiveness, the OECD and Banque de France use current weights (see Durand, et al. (1992)). However, a current weight based EER suffers from the criticism that the contemporaneous exchange rate and trade volume feed to each other which mixes the direction of causality in the first place. On the other hand the advantage of using a fixed weight lies in the fact that the rate of variation in the EER remains the same irrespective of whether indexed or actual value of exchange rates are used. In addition, with constant weight, any year can be selected to index the resulting EER series.

In respect to the weighting system, the preferred mathematical formula is "geometric", but an arithmetic formula is also used as in the case of the Federal Reserve Board of the United States.

Another important question is about the selection of period to draw the trade-related weights. It can be a single year or an average of some specified period. In the case of India it is found that the trade weights do not change too much from year to year but can change substantially from month to month. Selecting one particular year, as the representative year is problematic, and would be highly subjective, considering the fact that there are six different countries involved in the process. Therefore, the average trade volume of the G5 countries during the period 91-92 to 97-98 is used to calculate the weights. A similar procedure is followed in the Reserve Bank of India (RBI 1993; RBI 1998c).

The effective nominal exchange rate (NEER) is calculated in terms of unit of G5 composite currency (G5C) per unit of rupee. The NEER is weighted by the domestic wholesale price index (WPI) and the composite consumer price index of G5 to get the real effective exchange rate (REER). Domestic WPI is used instead of domestic CPI in order to give export orientation to REER. Moreover, the WPI for India can be

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[85] Indian Rupee is free floating since March 1993 (GOI 1996:103)

[86] Several possibilities exist in using trade-based weights, like import weights, export weights, multilateral weights, and elastic weight.

considered a closer equivalent to the underlying CPI of developed countries, as discussed in Chapter 4. The weight and the formulae used for calculating CPIG5, WPIG5, IPIG5, NEER, REER are as follows.

Trade Weights (w_i)

USA	Germany	Japan	UK	France
0.394	0.194	0.184	0.168	0.060

World Consumer Price index (CPIG5) $CPI^* = \prod_{i=1}^{5} (CPI_i)^{w_i}$

World producer price index (WPIG5) $WPI^* = \prod_{i=1}^{5} (WPI_i)^{w_i}$

World industrial production index (IPIG5) $IPI^* = \prod_{i=1}^{5} (IPI_i)^{w_i}$

Effective relative price $ERP = \frac{WPI}{CPI^*} = \prod_{i=1}^{5} (\frac{WPI}{CPI_i})^{w_i}$

Effective exchange rate 0f G5 countries in terms of units of SDR $e^* = \prod_{i=1}^{5} (e_i)^{w_i}$

$$NEER = \frac{e}{e^*} = \prod_{i=1}^{5} (\frac{e}{e_i})^{w_i} \text{ where, weight } w_i = \frac{X_i}{\sum_{i=1}^{5} X_i}; \quad \text{and } \sum_{i=1}^{5} w_i = 1$$

Real effective exchange rate $REER = NEER * ERP = NEER * \frac{WPI}{CPI^*}$

Where, suffix $i = USA, Germany, UK, Japan, France$; e is the exchange rate of the Indian rupee expressed in terms of SDR per unit of national currency (SDR/nc); e_i is the exchange rate of the i^{th} country currency in terms of SDR/nc. X_i is the average merchandise trade between India and country 'i' during the period 1991-97. A '*' on the variable indicates that it is a world value represented by the G5 countries composite value, e.g. e^* represents units of SDR per unit of G5C. The NEER is units of composite currency G5C per unit of rupee. Thus, an increase in NEER or REER represents appreciation of the rupee and therefore a fall in competitiveness. All the variables are taken from the International Financial Statistics (IFS), that is, IPI: line

62, WPI: line 63, CPI: line 64 and exchange rate: line aa. All these data series are first generated at monthly frequency and then converted to annual frequency by taking averages.

Table AA.1 Sources of data

Sl. No.	Document or database used	Abbreviated as	Details of the organization of origin of documents and databases
1	Handbook of Statistics on Indian Economy 1998, 2000	RBI-A	Reserve Bank of India, Mumbai.
2	RBI Bulletin various issues	RBI-B	-DO-
3	Economic Survey various issues	ES	Office of economic adviser (OEA), Ministry of Finance, government of India.
4	National Accounts Statistics: Sources and Methods	CSO-SM	Central Statistical Organization (CSO), Department of Statistics, Ministry of Planning and Program implementation, government of India
5	National Accounts Statistics	CSO-NAS	-DO-
6	World Development Indicators 2000, CDROM	WDI2000	The World Bank
7	International Financial Statistics, various issues	IFS	International Monetary Fund, Washington DC.
8	ECON-DATA	ECONDATA	EconData Pty Ltd, A.C.N. 006463092, 31 Beatty Avenue Armadale Victoria 3143, Australia. Tel (03) 9824-7393 Fax (03) 9822-9038
9	NCAER	NCAER	National council of applied economic research, New Delhi

Table AA.2Basic data: definitions and sources

Symbol	Variable description and unit of measurement	Data Source
CA	Current account deficit (rupees million) as on March 31.	RBI-A, B
CAZ	Current account deficit as a fraction of gross domestic product. CAZ=CA/GDP	Calculated
CBDN	Bank density: population (thousands) per branch of commercial bank calculated as CBDN = (1000*POP)/CBPOP.	Calculated
CBPOP	Number of Branches of Commercial Banks (as on June 30)	ES
CGAP	Combined gap (CGAP) between total outlay and current revenue of central and state governments and union territories (including internal and extra-budgetary resources of public sector undertakings for their plans) (rupees million).	ES
CGAPZ	Fiscal Deficit: Combined gap between total outlay and current revenue as fraction of gross domestic product. CGAPZ=CGAP/GDP	Calculated
CGS1	Bond rate: Yield on 1-5 Year Government of India (GOI) Securities, taken in fractions. Middle point has been taken for the data given in range.	RBI-A, B
CPIG5	Consumer Price Index of G5 Countries (base: 1993-94=100) calculated by taking average of the monthly series created for CPIG5.	Refer section AA.3.3
CRR	Cash Reserve Ratio: average of the notified values announced by the RBI during the financial year. This is the statutory deposit commercial banks are required to keep with the RBI as the fraction of their time plus demand deposits.	RBI-A
DR1	Annual interest rate on 1-3 Year commercial banks deposits taken in fraction.	RBI-A
DRAIN	Fraction change in rainfall index from the 50-year average index for June-Sep. DRAIN = (RAINA – RAINN)/RAINN	Calculated
E	Exchange rate in terms of SDR/Rs calculated as average of monthly data given in IFS: M534.AA after inverting.	Calculated from IFS
EG5	Effective exchange rate of G5 countries in terms of SDR/ G5C: calculated by geometrically weighting IFS line aa SDR monthly rates of G5 countries by their relative trade share with India. The monthly series is then used to get the annual rate by averaging over the financial year. G5C represents effective G5 currency.	Refer section AA.3.3
FDINZI	Foreign direct investment, net inflows as fraction of GDI. Line BX.KLT.DINV.DT.GI.ZS of WDI 2000	WDI 2000

Symbol	Variable description and unit of measurement	Data Source
FERU	Gross international reserves (includes gold) measured in current US$ millions. Line FI.RES.TOTL.CD of WDI 2000	WDI 2000
GDIZPB	Gross domestic investment in public sector as fraction of GDP	ES
GDIZPV	Gross domestic investment in private sector as fraction of GDP	ES
GDP	GDP at market prices at current prices (rupees million). Line NY.GDP.MKTP.CN of WDI 2000	WDI 2000
GNSZ	Gross national savings including NCTR (current prices) as a fraction of GDP. Line NY.GNS.ICTR.ZS of WDI 2000	WDI 2000
IPIG5	Industrial Production Index of G5 countries calculated by taking the average of the monthly series of IPIG5. The monthly IPIG5 series is trade weighted geometric mean of indices given in line 66 of IFS. Base: 993-94=100	Refer section AA.3.3
LABT	Total labour force (million). Line SL.TLF.TOTL.IN of WDI 2000.	WDI 2000
LIT	Literacy rate among total young adult as fraction of people aged above 15 years. Calculated from illiteracy rate, line SE.ADT.ILIT.ZS of WDI 2000.	WDI 2000
M0	Base (Reserve) Money (rupees million). M0 = Currency with the Public (CUP) + Currency in hands of commercial banks (CIB) + Bankers' Deposits with RBI (BDR) + Other Deposits with RBI (ODR)	RBI-A&B
M1	Narrow Money (rupees million). M1 = Currency with the Public + Demand Deposits with Banks (DD) + Other Deposits with RBI	RBI-A&B
M3	Broad Money (rupees million). M3 = M1 + Time Deposits with Banks	RBI-A&B
NEER	Nominal Effective Exchange rate (NEER) in terms of G5C / Rs calculated as NEER = E/EG5.	Refer section AA.3.3
NFCS	Estimated net fixed capital stock at 1993-94 prices with 5% depreciation (rupees million). Refer appendix section AA.3.1.	Calculated
P	Wholesale price index (WPI) of all commodities (average of the weeks) converted to base 1993-94 = 100	ES
PEO	Wholesale price index of edible oil prices (average of the weeks) converted to base 1993-94 = 100	ES
PG5	Producer Price Index of G5 Countries (base: 1993-94=100); calculated from the monthly series, which is constructed by geometrically weighting IFS line 63 indexes of G5 countries by their relative trade share with India.	Refer section AA.3.3
PMO	Wholesale price index for mineral oil (average of the weeks) included in the basket of general WPI at base 1993-94 = 100	ES

Symbol	Variable description and unit of measurement	Data Source
POP	Population in millions (mid year estimate) IFS line: A534.99Z. Downloaded from ECON-DATA at RSPAS, ANU, 24-Jan-2000.	IFS: A534.99Z
RAINA	Actual rainfall index based on food grain un-irrigated acerage weights for the period June-Sep.	NCAER
RAINN	Normal rainfall index = 823 (50 years (June-Sep) average).	NCAER
REER	Real Effective Exchange rate of G5 Countries. Refer appendix, section AA.3.3.1	Calculated
RGDFI	Real gross domestic fixed investment. Line NE.GDI.FTOT.KN of WDI 2000	WDI 2000
RGDPF	Real GDP at factor cost (rupees million). Line NY.GDP.FCST.KN of WDI 2000	WDI 2000
RIM	Imports of goods and services at constant price (rupees million). Line NE.IMP.GNFS.KN of WDI 2000.	WDI 2000
LRSBI	Average annual lending rate of State Bank of India (SBI) expressed as fraction. For the data given in ranges the middle point is taken.	RBI-A & C
SLR	Statutory Liquidity Ratio according to the RBI notifications	NCAER
TOT	Terms of trade calculated as TOT = Unit value index of export (UVIE)/ Unit value index of imports (UVII). Base: 1993-94	ES
UTID	Unit Trust of India (UTI) annual dividend rate expressed as fraction	RBI-A
WAGP	Emoluments of public sector employees expressed as rupees per capita	ES
Y	Gross domestic product at constant market prices (rupees millions). Line NY.GDP.MKTP.KN of WDI 2000.	WDI 2000
YP	Permanent real income calculated according to the error-learning hypothesis discussed in Ladler (1989:88) with geometric wt for last 10 years and weight of 0.5 for current year's real GDP at factor cost (RGDPF).	Refer to section AA.3.1
YPC	Real income per capita (rupees per person) calculated as YPC = Y/POP	Calculated

Table AA.3 Basic (untransformed) dataset used in regression analysis

OBS.	GDP	RGDPF	Y	YP	POP	P	PEO	PMO	GDIZPV	GDIZPB	GNSZ	DRAIN	LIT	TOT
	Rs Million	Rs Million	Rs Million	Rs Million	Million	Index	Index	Index	Fraction	Fraction	Fraction	Fraction	Fraction	Ratio
1970	466848	3021486	3330022	2881045.54	539.08	14.35	15.08	8.91	0.1060	0.0650	0.15613	0.16660	0.3310	0.8795
1971	500325	3051993	3390504	2965460.84	551.23	15.15	13.27	9.62	0.1140	0.0710	0.16850	0.11669	0.3380	0.9681
1972	551692	3042270	3369577	3002784.71	563.53	16.67	14.93	9.98	0.0980	0.0730	0.16013	-0.21125	0.3460	1.0335
1973	670670	3180737	3469121	3090625.18	575.89	20.04	22.32	12.65	0.1060	0.0770	0.17147	0.12592	0.3540	0.8782
1974	792152	3217660	3510482	3152920.26	588.30	25.09	25.95	21.39	0.1220	0.0760	0.18293	-0.13527	0.3610	0.6369
1975	851923	3507392	3833096	3328979.21	600.76	24.82	20.36	22.90	0.1120	0.0960	0.20265	0.17600	0.3690	0.5844
1976	918261	3551231	3901200	3438916.28	613.27	25.33	21.57	23.88	0.1080	0.1010	0.21680	0.05114	0.3780	0.6408
1977	1039115	3816504	4181927	3626424.55	625.82	26.65	26.55	23.88	0.1160	0.0820	0.20587	0.04949	0.3860	0.7869
1978	1126978	4026510	4423231	3825148.36	646.00	26.65	23.98	24.06	0.1280	0.0950	0.21471	0.12570	0.3940	0.6901
1979	1236939	3817072	4191093	3819705.13	660.00	31.22	29.11	27.53	0.1250	0.1030	0.21757	-0.19258	0.4020	0.6375
1980	1471194	4090765	4468403	3953759.72	675.00	36.75	34.39	36.89	0.1230	0.0870	0.19063	0.12617	0.4100	0.5582
1981	1728055	4340100	4760365	4145439.42	690.00	40.36	39.37	44.64	0.1340	0.1040	0.21486	0.01952	0.4190	0.6436
1982	1926776	4474624	4940366	4308546.24	705.00	42.33	41.34	45.98	0.1140	0.1110	0.20551	-0.09196	0.4270	0.6683
1983	2245400	4840506	5307266	4572973.15	720.00	45.52	46.06	47.32	0.1110	0.1000	0.19371	0.22374	0.4360	0.8284
1984	2502337	5026555	5502476	4798193.00	736.00	48.47	49.61	47.77	0.1030	0.1080	0.19172	0.01602	0.4440	0.7248
1985	2836569	5231483	5803375	5013125.16	750.86	50.61	46.06	53.57	0.1300	0.1120	0.21301	-0.05940	0.4520	0.7424
1986	3168702	5455523	6085975	5232589.99	767.20	53.55	56.69	56.25	0.1150	0.1170	0.20520	-0.07334	0.4610	0.8883
1987	3604090	5691124	6376229	5459993.58	783.73	57.95	69.29	56.25	0.1260	0.0990	0.19875	-0.17247	0.4690	0.8427
1988	4281002	6297219	7008973	5876640.47	800.50	62.27	66.93	57.59	0.1440	0.0990	0.20724	0.17680	0.4780	0.8640
1989	4941235	6731333	7469634	6302122.72	817.49	66.87	70.08	58.04	0.1410	0.1000	0.20907	0.01239	0.4860	0.8358
1990	5792639	7092203	7892483	6695165.50	834.70	73.73	87.80	69.20	0.1550	0.0970	0.21367	0.12874	0.4930	0.7541
1991	6671647	7150009	7925894	6920468.09	851.66	83.86	104.72	80.36	0.1350	0.0920	0.21375	0.02169	0.5020	0.8250
1992	7635609	7526150	8355510	7221123.93	867.82	92.29	104.33	91.07	0.1510	0.0890	0.21596	-0.01334	0.5090	0.8789
1993	8769520	7990770	8769520	7603583.37	883.91	100.00	100.00	100.00	0.1300	0.0820	0.19959	0.06413	0.5170	1.0000
1994	10378420	8610640	9463351	8104657.20	899.95	110.86	110.24	104.91	0.1480	0.0880	0.21524	0.23123	0.5250	1.0515
1995	12179630	9264120	10222850	8681834.00	915.97	119.37	118.90	104.91	0.1890	0.0760	0.23558	0.04280	0.5330	0.9521
1996	14098490	9989780	10964331	9333143.38	939.41	126.96	118.50	120.54	0.1490	0.0700	0.21780	0.08952	0.5410	0.8712
1997	15635520	10491910	11510140	9909747.77	955.12	133.09	117.72	134.38	0.1670	0.0670	0.21933	0.08490	0.5490	1.0064
1998	18060166	11121425	12210365	10512511.37	970.93	142.29	137.40	137.05	0.1520	0.0660	0.22360	0.10389	0.5570	
1999						147.00	120.61	153.35						

OBS.	UTID	CGAP	CGAPZ	CBDN	CMR	DR1	LRSBI	CGS1	RGDFI	NFCS	LABT	FDINZI	RIM
	Fraction	Rs Million	Fraction	Th/branch	Fraction	Fraction	Fraction	Fraction	Rs Million	Rs Million	Million	Fraction	Rs Million
1970	0.0800	22880	0.0490	47.7993	0.0638	0.0625	0.0750	0.04065	552597	6821275	240.9304	0.00443	248659.2
1971	0.0825	30590	0.0611	42.4513	0.0516	0.0600	0.0850	0.04190	586834	7067045	246.5177	0.00396	298235.1
1972	0.0850	34240	0.0621	38.8641	0.0415	0.0600	0.0850	0.04720	617160	7330853	252.1772	0.00153	283789.4
1973	0.0850	29730	0.0443	34.8961	0.0783	0.0600	0.0875	0.04760	610962	7575273	257.9367	0.00249	322633.1
1974	0.0860	39290	0.0496	34.7367	0.1282	0.0675	0.1125	0.05325	592170	7788680	263.8428	0.00298	285646.2
1975	0.0875	48380	0.0568	32.0747	0.1055	0.0800	0.1400	0.05620	649376	8048621	269.9220	0.00426	281189.9
1976	0.0900	54370	0.0592	28.9006	0.1084	0.0800	0.1400	0.05385	731173	8377363	276.1583	0.00246	281561.3
1977	0.0900	60200	0.0579	25.2326	0.0928	0.0600	0.1300	0.05325	801271	8759766	282.5388	-0.00154	370018.0
1978	0.0900	89270	0.0792	23.0583	0.0757	0.0600	0.1300	0.05300	808761	9130539	289.0539	0.00060	370018.0
1979	0.1000	85720	0.0693	21.8529	0.0847	0.0700	0.1650	0.05220	785296	9459308	295.6892	0.00143	430697.4
1980	0.1150	122820	0.0835	20.8211	0.0712	0.0800	0.1650	0.05375	870872	9857214	302.4261	0.00208	509389.1
1981	0.1250	133130	0.0770	19.3239	0.0896	0.0850	0.1650	0.05830	930629	10294983	302.2131	0.00205	542125.3
1982	0.1350	169520	0.0880	17.9953	0.0878	0.0850	0.1650	0.06720	970964	10751198	308.9230	0.00164	516652.8
1983	0.1400	198400	0.0884	17.1107	0.0863	0.0850	0.1650	0.05780	982100	11195738	315.6509	0.00013	564271.3
1984	0.1425	257260	0.1028	16.2358	0.0995	0.0850	0.1650	0.06255	1020281	11656233	322.3611	0.00044	597966.7
1985	0.1525	271880	0.0958	14.6124	0.1000	0.0875	0.1650	0.07630	1092865	12166287	329.0132	0.00194	676760.1
1986	0.1600	359670	0.1135	14.4035	0.0999	0.0875	0.1650	0.08345	1193057	12751029	336.2140	0.00211	727329.9
1987	0.1650	386850	0.1073	14.5566	0.0988	0.0950	0.1650	0.11320	1324238	13437716	343.4324	0.00348	714892.5
1988	0.1800	443340	0.1036	14.4469	0.0977	0.0950	0.1650	0.15455	1417536	14183367	350.7037	0.00129	828390.2
1989	0.1800	549930	0.1113	14.1684	0.1149	0.0950	0.1650	0.12960	1540597	15014795	357.9900	0.00361	823511.4
1990	0.1950	659410	0.1138	14.0550	0.1585	0.0950	0.1650	0.14370	1693321	15957377	356.7963	0.00204	850217.1
1991	0.2500	655360	0.0982	14.1495	0.1957	0.1200	0.1650	0.17315	1625543	16785051	372.6081	0.00123	748800.5
1992	0.2600	714930	0.0936	14.3089	0.1442	0.1100	0.1900	0.16425	1738727	17684526	379.3890	0.00448	878084.9
1993	0.2600	886270	0.1011	14.4763	0.0699	0.1000	0.1900	0.12360	1834180	18634480	386.2260	0.00948	987245.6
1994	0.2600	985710	0.0950	14.5642	0.0940	0.1100	0.1500	0.10755	2041520	19744276	392.8480	0.01284	1160311.6
1995	0.2000	988850	0.0812	14.6917	0.1773	0.1200	0.1650	0.10140	2428260	21185322	399.6239	0.02299	1400790.1
1996	0.2000	1159160	0.0822	14.9317	0.0744	0.1150	0.1450	0.10710	2582380	22708436	406.6131	0.02639	1544550.7
1997	0.2000	1401500	0.0896	15.0477	0.0803	0.1075	0.1400	0.11595	2716530	24289545	423.4462	0.03638	1747316.0
1998	0.1350	1807710	0.1001	15.1452	0.0818	0.1000	0.1200	0.11380	2870119	25945186	431.0561	0.02595	1956364.2
1999	0.1375				0.0907	0.0900							

OBS.	M0	M1	M3	WAGP	CRR	FERU	NEER	REER	CA	CAZ	IPIG5	CPIG5
	Rs Million	Rs Million	Rs Million	Rupee	Ratio	US$ Million	G5C/Rs	Number	Rs Million	Fraction	Index	Index
1970	48230	73740	110200		0.0300	1023.20	0.479040	0.257500	-4454	-0.0095406	62.16	26.69
1971	53820	83230	126930	5920	0.0300	1245.80	0.468390	0.251750	-4987	-0.0099675	63.33	28.19
1972	60330	97000	150130	5805	0.0300	1367.60	0.433040	0.243820	-3114	-0.0056445	68.80	29.61
1973	72730	112000	176240	5573	0.0600	1629.30	0.405330	0.250570	11352	0.0169260	73.00	32.42
1974	76040	119750	195490	7402	0.0450	2324.70	0.404220	0.276020	-9557	-0.0120650	69.81	36.75
1975	78080	133250	224800	8983	0.0400	2064.40	0.379380	0.231360	-1779	-0.0020882	66.55	40.70
1976	97980	160240	277810	8940	0.0525	3728.80	0.378210	0.218380	8943	0.0097391	72.18	43.88
1977	109410	143880	329060	10048	0.0600	6085.40	0.376710	0.213000	11241	0.0108180	75.20	47.14
1978	140840	172920	401120	11210	0.0600	8316.10	0.359670	0.190980	-2379	-0.0021110	79.20	50.20
1979	165730	200000	472260	12468	0.0600	11815.40	0.362450	0.205010	-5533	-0.0044731	82.29	55.19
1980	194520	234240	557740	14239	0.0600	12009.80	0.365290	0.219260	-22135	-0.0150460	79.72	61.23
1981	209980	249370	627520	16158	0.0719	8108.80	0.356550	0.216700	-28389	-0.0164280	80.15	66.40
1982	231100	285350	731840	18029	0.0713	8241.60	0.350280	0.212200	-32801	-0.0170240	77.91	69.88
1983	289940	333980	865250	21549	0.0813	8215.70	0.338080	0.212490	-33161	-0.0147680	82.11	72.43
1984	352160	399150	1029330	24328	0.0875	8535.90	0.314500	0.202970	-28726	-0.0114800	85.62	75.10
1985	381650	440950	1193940	25887	0.0900	9493.10	0.285580	0.186240	-59558	-0.0209960	88.15	77.60
1986	448080	515160	1416320	28820	0.0925	10480.10	0.237310	0.161740	-58300	-0.0183990	89.20	78.57
1987	534890	585550	1642750	32537	0.0975	11511.70	0.215200	0.154580	-62926	-0.0174600	93.14	80.67
1988	629580	667860	1934930	39415	0.1050	9185.80	0.190620	0.142420	-115801	-0.0270500	97.76	83.34
1989	775910	810600	2309500	43665	0.1300	8048.50	0.172160	0.132110	-113886	-0.0230480	100.18	87.14
1990	877790	928920	2658280	49179	0.1500	5637.40	0.149770	0.120780	-173685	-0.0299840	101.54	91.43
1991	995050	1144060	3170490	56508	0.1500	7616.00	0.111620	0.098921	-22373	-0.0033534	100.50	94.62
1992	1107790	1240660	3668250	64983	0.1500	9538.80	0.101490	0.096008	-127635	-0.0167160	99.95	97.56
1993	1386720	1507780	4344070	72043	0.1425	14674.60	0.086303	0.086303	-36358	-0.0041460	100.00	100.00
1994	1692820	1922570	5314260	82517	0.1475	24220.90	0.082743	0.089769	-105826	-0.0101970	105.09	102.18
1995	1944570	2148350	6040070	106876	0.1450	22864.60	0.075726	0.086691	-196067	-0.0160980	107.23	104.27
1996	1999850	2406150	7018480	110662	0.1164	24889.40	0.074637	0.089050	-162820	-0.0115490	110.79	106.41
1997	2264020	2678440	8213320	129582	0.1000	28385.40	0.074357	0.091111	-208830	-0.0133560	114.84	108.62
1998	2593450	3088010	9786330	142922	0.1050	30646.60	0.065899	0.085165	-167870	-0.0092950	115.41	110.10
1999	2802420	3397770	11117070		0.0950	36005.30	0.064109	0.085135			117.52	111.15

AB: Quantitative Methods

A variety of principles, ideas and econometric methodologies popular in applied economics have been used in this thesis. Several, such as ordinary least squares estimation are so common they need no extra elaboration, while some, such as causality tests, have been elaborated at the first appropriate place of application. Yet, several principles are referred to in this appendix for more detail. Therefore, an attempt is made in this section to provide more information on such econometric methods as unit root tests, error correction representation, cointegration, cointegrated vector error correction models, generalized restrictions for structural design of cointegrating vectors, generalized impulse response function, Hendry methodology, and some of the diagnostic tests.

AB.1 ADF BASED UNIT ROOT TEST

Unit root is considered to characterizes a series if the data generating process (DGP) can be written as:

$$(1-L)y_t = \mu + \upsilon_t$$
$$\text{with } \mu = a,\ \mu = \beta t,\ \mu = 0,\ t = 1,2.....,n \qquad \text{(AB.1)}$$

Where a and β are constants, υ_t is a stationary process and L is a lag operator. Condition $\mu = a$, is a case of random walk with drift, $\mu = \beta t$ is a trend stationary process and $\mu = 0$ is pure random walk. In all cases, the characteristic equation has a single root equal to 1; hence the name. Basically, the presence of unit root in a time series indicates a completely unsystematic motion of a variable from its previous point, such as random walk, with or without drift. Such variables are called non-stationary. However, they can be made stationary by differencing or sometimes de-trending. As a common definition, a data series is said to be integrated of order d denoted with I(d), if it requires to be differenced d times to achieve a stationary series. In the real world, most macroeconomic time series data as in the present study are found to be I(1). The presence of such variables in a regression needs to be treated carefully as it can result in spurious results as demonstrated in Granger and Newbold (1974). Particularly, $\mu = a$ in equation (AB.1) produces a trend and therefore those series characterized by $\mu = a$ and $\mu = \beta t$ are likely to produce significant relationship as a result of underlying trend, whether or not there is any regression at work (Greene 1997). If a structural variable such as real output, is truly I(1), shocks to it will have permanent effects and such observation would have serious consequences for macroeconomic policy analyses. However, when two I(1) series are such that there exists a linear combination of their values producing series of stationary residuals, they are said to be cointegrated and the resulting regression will be super consistent (Engle and Granger 1987; Hamilton 1994). Cointegration will be discussed in more detail in the following section.

Therefore, as an essential step of analyzing time series properties, all the variables in this study are tested for stationarity using unit root tests. There are several versions of testing unit root. However, in this study, the augmented Dickey-Fuller (ADF) unit root test has been uniformly used in two versions, one with intercept only and the other with intercept and trend included in the regression. The ADF test is proposed to accommodate error autocorrelation by adding lagged differences of the time series y_t under examination as the following Dickey-Fuller (DF) specification.

$$\text{Dickey-Fuller (DF): } y_t = \alpha + (1-\phi)\delta t + \phi\, y_{t-1} + \varepsilon_t \quad t = 1,\ldots\ldots,n \qquad \text{(AB.2)}$$

$$\text{ADF: } y_t = \alpha + (1-\phi)\delta t + \phi\, y_{t-1} + \sum_{i=1}^{p+1} \phi_i y_{t-i} + \varepsilon_t \qquad \text{(AB.3)}$$

Which can also be written as:

$$\text{ADF: } \Delta y_t = \alpha + \rho\delta t - \rho\, y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t, \ t = 1,\ldots\ldots,n \qquad \text{(AB.4)}$$

Where ε is iid. A series is said to be trend stationary if $|\phi| < 1$, while it is difference stationary if $\phi = 1$ with non-zero drift α. Attempts to distinguish the difference stationary process from the trend stationary series have generally taken the form of a (one-sided) test of the null hypothesis of a unit auto regressive root against the alternative of stationarity as follows.

$$H_0 : \phi = 1 \text{ against } H_1 : \phi < 1 \quad \text{(AB.5)}$$

In the case of equation (AB.4), the null hypothesis is

$$H_0 : \rho = 1 - \phi = 0 \quad \text{(AB.6)}$$

It is important to note that the estimator of ϕ is biased downwards and standard t-statistic for hypothesis test is not applicable. Therefore, critical values of the non-standard Dickey-Fuller unit root distribution are used rather than the standard normal distribution.

Although, ADF based unit root test is the most common tool of examining time series properties, it has some limitations. It is not considered very powerful in finite sample for alternatives $H_1 : \phi = \phi_0 < 1$ when ϕ_0 is near unity. In addition, there is a size-power trade-off depending on the augmentation (p) used in dealing with the problem of residual serial correlation. In the case of autocorrelated disturbances, the size distortion of the uncorrected DF test is considerable. The ADF(p) test performs better, and with a sufficiently high enough value for p. However, this happens at the expense of power. The ADF test with large value of p relative to the sample size has almost no power. Since the true order of p is not known, the two step procedure is recommended, whereby model selection criterion such as the Akaike information criterion (AIC) or the Schwarz Bayesian criterion (SBC) are used to select the order of the ADF regression, and the test is then performed (Pesaran and Pesaran 1997). Therefore, in this study, the ADF test is carried out with two-step procedure.

Some times a data series may have experienced one period shock or a permanent change in the level resulting into structural break. In such a situation, the ADF test may have a bias towards accepting the null of a unit root as demonstrated in Perron (1989). Therefore, it is possible to confuse a structural break and unit root. In the presence of a suspected structural change, a trend stationary series can be mistaken as non-stationary. In such a situation if the analysis is predominantly contingent upon series being I(1), it may lead to erroneous conclusions. However, it is also important to note that it is extremely difficult to ascertain structural break in a small data set. In the light of such problems, most of the analysis and policy conclusion in this study are carried out based on economic relationship rather than the time series property of any individual variables.

AB.2 CONCEPT OF ERROR CORRECTION REPRESENTATION

The concept of error correction model (ECM) can be presented in a simplified way using a two variable dynamic system as follows, where the current value of y is affected by its own one period lagged value and current and one period lagged value of x.

$$y_t = \alpha + \beta_0 x_t + \beta_1 x_{t-1} + \gamma y_{t-1} + \varepsilon_t \qquad \text{(AB.7)}$$

Which can be written as:

$$y_t - y_{t-1} = \alpha + \beta_0 x_t - \beta_0 x_{t-1} + \beta_1 x_{t-1} + \beta_0 x_{t-1} + \gamma y_{t-1} - y_{t-1} + \varepsilon_t \qquad \text{(AB.8)}$$

$$\text{Or} \quad \Delta y_t = \alpha + \beta_0 \Delta x_t + (\beta_1 + \beta_0) x_{t-1} + (\gamma - 1) y_{t-1} + \varepsilon_t \qquad \text{(AB.9)}$$

$$\text{Or} \quad \Delta y_t = \alpha + \beta_0 \Delta x_t + \left|(\beta_1 + \beta_0) \quad (\gamma - 1)\right| \begin{vmatrix} x_{t-1} \\ y_{t-1} \end{vmatrix} + \varepsilon_t \qquad \text{(AB.10)}$$

If x and y have long-term association represented by cointegrating vector $((\beta_1 + \beta_0) \quad (\gamma - 1))$ then in the steady state Δx and Δy are zero and the long term multiplier is obtained as $\frac{\partial y_{t-1}}{\partial x_{t-1}} = -\frac{\beta_0 + \beta_1}{\gamma - 1} = \tau$. Now suppose the cointegrating vector is normalized by $(\gamma - 1)$ such that $y_{t-1} = \tau x_{t-1} + \vartheta_{t-1}$ then the estimated error term $\hat{\vartheta}_{t-1}$ must be stationary and can be consistently plugged in to the above equation to obtain:

$$\Delta y_t = \alpha + \beta_0 \Delta x_t + (1 - \gamma)(y_{t-1} - \tau x_{t-1}) + \varepsilon_t = \alpha + \beta_0 \Delta x_t + (1 - \gamma)\hat{\vartheta}_{t-1} + \varepsilon_t \qquad \text{(AB.11)}$$

Equation (AB.11) is the error correction representation of model (AB.7), which can be consistently estimated and provides short-term dynamics as well as long-term adjustment coefficient. The coefficient $(1 - \gamma)$ gives speed of adjustment at which the variables achieve steady state. The short-term multiplier is given by $\frac{\partial \Delta y_t}{\partial \Delta x_t} = \beta_0$.

Davidson, et al. (1878) proposed an economic interpretation of error correction representation as cited in Hamilton (1994: 581). They examined a relationship between the log of consumption spending and the log of income in a homogeneous ECM ($\tau = 1$). For $(1 - \gamma)$<0, the model asserts that if y (say consumption) had previously been larger than the normal share of x (say income) (so that $\hat{\vartheta}_{t-1}$ is larger than normal), then that causes y to be lower for any given value of the other explanatory variables. The coefficient of error term gives correction to the dependent variables for this error. It may be noted that for stability of the basic system absolute value of coefficient γ must be less than one, which implies that the value of coefficient $(1-\gamma)<0$ must lie between zero and minus two.

It is consistent to separately estimate the cointegrating vector $((\beta_1+\beta_0) \quad (\gamma-1))$ and use the error correction term in the dynamic model with Δy as the dependent variable. Such a procedure of ECM is known as two-step error correction modeling largely due to Engle and Granger (1987).

AB.3 COINTEGRATION AND VECTOR ERROR CORRECTION REPRESENTATION

A (n x 1) vector time series y_t is said to be cointegrated if each of the series taken individually is I(1), that is, nonstationary with a unit root, while some linear combination of the series $a'y_t$ is stationary or I(0) for some nonzero (n x 1) vector 'a'. In the case of a single equation, the residual-based method of testing cointegration proposed by Engle and Granger (1987) is common, where residuals are tested for unit root using the augmented Dickey-Fuller (ADF) test. The variables are cointegrated if residuals are found to be stationary. However, when the number of I(1) variables in the equation is more than two, this method is not efficient (Pesaran and Pesaran 1997:291). Further, it is important to note that the critical values for testing unit root for residuals, when there are more than two I(1) variables in the equation, are not the same as those used for testing unit root of a single variable case. With a small data set and a large number of I(1) variables in the system, this method is likely to be even more inefficient.

As discussed above in a specific representation, distributed lag models can be rearranged to incorporate variables in their levels as well as their differences, allowing the analysis of both short-run and long run properties of the variables. When this is done in a vector autoregressive (VAR) framework, the resulting error correction representation is called the Vector Error Correction model (VECM). Whether the variables in the VAR are cointegrated, can be tested using Johansen's maximum likelihood procedure (Johansen 1988, 1991), which is considered to be a more efficient method. Drawing on Hamilton (1994: chapters 18, 19), Johansen (1995: Chapter 4), Pesaran & Smith, (1998), Pesaran and Shin (1998), a brief description of a cointegrated vector error correction model (VECM) with generalized restrictions as used in this thesis for empirical analysis is presented below.

Suppose y_t is a $mx1$ vector of all jointly determined endogenous variables, which can be represented as a non-stationary p th-order augmented vector auto regression:

$$\Phi(L)y_t = a_0 + a_1 t + \Psi w_t + u_t \tag{AB.12}$$

Where $\Phi(L) \equiv I_n - \Phi_1 L - \Phi_2 L^2 - \cdots - \Phi_p L^p$; L is the lag operator such that $Ly_t \equiv y_{t-1}$; w_t is a $qx1$ vector of exogenous I(0) variables, u_t is a $mx1$ vector of unobserved disturbances. $\{\Phi_i, i = 1,2,\cdots p\}$ and Ψ are mxm and mxq coefficient matrices. The intercept and the trend coefficients a_0 and a_1 are $mx1$ vectors and, t is a linear time trend. The unobserved disturbances are assumed to satisfy the conditions: $E(u_t) = 0$; $E\left(u_t u_t'\right) = \Sigma$ for all t, where $\Sigma = \{\sigma_{ij}, i, j = 1,2\cdots,m\}$ is a $m \times m$ positive definite matrix, $E\left(u_t u_{t'}'\right) = 0$ for all $t = t'$ and $E(u_t|w_t) = 0$. The roots of $\left|I_m - \sum_{i=1}^{p} \Phi_i z_i\right| = 0$ satisfy $|z| > 1$ or $z = 1$.

Rearranging the VAR into its error correction form gives the following cointegrating vector error correction model (VECM) with I(1) endogenous variables and I(0) exogenous variables.

$$\Delta y_t = a_0 + a_t t - \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \Psi w_t + u_t \tag{AB.13}$$

Here $\Pi = \Phi(1)$ is s long run multiplier matrix of order $m \times m$, Πy_{t-1} is an error correction term and $\Gamma_i = -\sum_{j=i+1}^{p} \Phi_j$ for $i = 1,\cdots,p-1$ are $p-1$ matrices of order $m \times m$ representing short-run dynamics of the system. The necessary and sufficient condition for cointegration is $|\Pi| = 0$. The matrix Π must have a rank less than m. For $rank(\Pi) = r < m$ there exist r linearly independent cointegrating vectors. Existence of r cointegrating vectors means that there exists $m \times r$ matrices β and α such that $\Phi(1) = \Pi = \alpha\beta'$ then $\Pi y_{t-1} = \alpha\beta' y_{t-1} = \alpha z_{t-1}$ where $z_{t-1} = \beta' y_{t-1}$ is the cointegrating relationship, often interpreted as deviation from equilibrium which is I(0) and α is now the matrix of adjustment in the VECM, which measure how strongly the deviation from equilibrium, the r stationary variables $\beta' y_{t-1}$, feedback onto the system. In view of the fact that most of the variables are expected to have deterministic trend, trend and the intercept terms are retained in the model. However, at the same time, to avoid any quadratic trend in the solution for y_t which may lead to changing nature of trend in y_t with a changing number of vectors (discussed in Pesaran and Smith (1998)), the coefficient of trend term is restricted by setting $a_1 = \Pi\gamma$ where γ is $m \times 1$ vector of unknown coefficients. With trend included in the vector of variables the coefficient matrix of cointegration will have a size of $(m+1) \times r$ and the estimated VECM is rewritten as follow:

$$\Delta y_t = a_0 - \alpha\beta_*^{'}(y_{t-1}^*) + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \Psi w_t + u_t \qquad \text{(AB.14)}$$

Here $y_{t-1}^* = (t, y_{t-1}^{'})'$ and $\beta_* = \begin{pmatrix} -\gamma' \\ I_m \end{pmatrix} \beta$. The VECM is estimated by maximizing the log likelihood function of the VECM for a selected rank of $\Pi_* = \alpha\beta_*^{'}$ which is equal to the number of cointegrating vectors. The VECM is estimated by maximizing the log Likelihood function of the VECM for a selected rank of Π which is equal to the number of cointegrating vectors. The number of cointegrating vectors is obtained by applying likelihood ratio tests on the maximum eigenvalue and trace of the stochastic matrix as follows (see Pesaran, et al. (2000), (Pesaran and Pesaran 1997). The test statistics are computed in Pesaran, et al. (2000).

The cointegration analysis requires all variables to be integrated of the same order, however, in practice, it is hard to find the relevant economic variables to comply with this requirement (Engle and Granger 1987). Johensen (1995), allows the I(0) variable to be used in cointegration analysis with other I(1) variables, while Granger (1997) cautioned against resulting complications in interpretation and

Levtchenkova, et al. (1998) argue that inclusion of I(0) variables may result in loss of information. Therefore, as far as possible, this thesis avoids such mixing in cointegration analysis.

Maximum Eigenvalue Statistics

Pesaran, et al. (2000), and (Pesaran and Pesaran 1997) discuss test statistics for a variety of cases in relation to the assumptions regarding trend and intercept terms in VECM and report critical values obtained from stochastic simulations. For the specific case of unrestricted intercept and restricted trend and without exogenous I(1) variables, followed in this thesis, the null hypothesis of r cointegrating relations and the calculation of test statistics can be presented as follows.

$$H_r : Rank(\Pi_y) = r \qquad \text{(AB.15)}$$

Against the alternative hypothesis

$$H_{r+1} : Rank(\Pi_y) = r+1 \qquad \text{(AB.16)}$$

For r = 0, 1, 2, ..., m-1, in the VECM (AB.14). Then the appropriate test statistics is given by the log-likelihood ratio statistics as

$$LR(H_r|H_{r+1}) = -n\log(1-\hat{\lambda}_{r+1}) \qquad \text{(AB.17)}$$

Where $\hat{\lambda}_t$ is the r[th] largest eigenvalue of the characteristic matrix defined as $S_{00}^{-1}S_{01}S_{11}^{-1}S_{10}$ with $S_{ij} = n^{-1}\sum_{t=1}^{n} r_{it}r_{jt}'$; $i, j = 0,1$; t = 1, 2, ...n; r_{0t} is the residual vector from OLS regressions of Δy_t on $(1, \Delta y_{t-1}, \Delta y_{t-2}, \ldots\ldots, \Delta y_{t-p+1}, w_t)$ and r_{1t} is the residual vector from OLS regressions of $\begin{vmatrix} t \\ y_{t-1} \end{vmatrix}$ on $(1, \Delta y_{t-1}, \Delta y_{t-2}, \ldots\ldots, \Delta y_{t-p+1}, w_t)$.

Trace Statistics

For testing the null hypothesis H(r) defined in (AB.15) against the alternative of trend-stationary, that is

$$H_m : Rank(\Pi_y) = m \qquad \text{(AB.18)}$$

For r = 0, 1, 2, ... m-1, in the VECM (AB.14). The log-likelihood ratio statistics for this test is given by

$$LR(H_r|H_m) = -n\sum_{i=r+1}^{m}\log(1-\hat{\lambda}_i) \quad \text{(AB.19)}$$

Where $\hat{\lambda}_{r+1}$, $\hat{\lambda}_{r+1}$ ... $\hat{\lambda}_m$ are the largest eigenvalues of $S_{00}^{-1}S_{01}S_{11}^{-1}S_{10}$

Generalized Restriction on Cointegrating Vectors

The structural estimation of the cointegrating relation requires maximization of a concentrated log-likelihood function subject to appropriate just-identifying or over-identifying restrictions on β. The direct procedure of identification as discussed in Pesaran and Smith (1998) and Pesaran and Pesaran (1997) is adapted, where long-run equilibrium properties of the underlying structural economic model are utilized in deciding the restrictions, while the likelihood ratio test statistics are used to examine the statistical acceptability of the restricted vector against the just identified vector.

AB.4 THE HENDRY METHODOLOGY OF GENERAL TO SPECIFIC MODELING

The general to specific methodology (GSM) of setting up a dynamic econometric model, formally discussed and summarized in Hendry and Richard (1982) and Hendry (1995), owes a lot to Sargan's (1964) paper and oral tradition developed largely at the London School of Economics (Pagan 1987). Therefore, this methodology is also known as Hendry methodology or London School of Economics methodology (LSM). The methodology essentially comprises the following four steps (Pagan 1995).

1. Formulate a general model that is consistent with what economic theory postulates are the variables entering any equilibrium relationship and which restricts the dynamics of the process as little as possible.
2. Reparameterize the model to obtain explanatory variables that are near orthogonal and which are 'interpretable' in terms of the final equilibrium.
3. Simplify the model to the smallest version that is compatible with the data ('congruent')

4. Evaluate the resulting model by extensive analysis of residuals and predictive performance, aiming to find the weakness of the model designed in the previous step.

Hendry favours starting with a sufficiently general model so that the need for a more general model should not be a surprise. The parameters must be estimable from the available data and the model should be logically identifiable, so that it is possible to learn about the parameters of interest using the model. Finally, the model must characterize the joint distribution of all the variables at the outset (Hendry 1995:270).

As an illustration based on economic principles, an econometric model can be written as an autoregressive distributed lag model as follows:

$$Y_t = \alpha + \sum_{i=1}^{m} A_i Y_{t-i} + \sum_{i=0}^{m} B_i X_{t-i} + \mu_t \qquad \text{(AB.20)}$$

Here α is a vector of constants, Y_t is $(n x 1)$ vector of endogenous variables, X_t is $(k x 1)$ vector of explanatory variables, A_i and B_i are $(n x n)$ and $(n x k)$ matrices of coefficients, and μ_t is a stochastic error term. As the second step, equation (AB.20) can be rearranged in many different ways, all of which would yield the same estimates of the unknown parameters, but each of which package the same information differently and consequently may be easier to interpret and understand. Generally, Hendry prefers to rewrite equation (AB.20) in an error correction mechanism (ECM) (Pagan 1995:11). The unrestricted error correction model (UECM) in terms of differences and lagged levels as one of the alternative representation of (AB.20) may look as follows.

$$\Delta Y_t = \alpha + \sum_{i=1}^{m-1} A_i^* \Delta Y_{t-i} + \sum_{i=0}^{m-1} B_i^* \Delta X_{t-i} + C_0 Y_{t-m} + C_1 X_{t-m} + \mu_t \qquad \text{(AB.21)}$$

where $C_0 = -\left(I - \sum_{i=1}^{m} A_i \right)$, $C_1 = \left(\sum_{i=0}^{m} B_i \right)$, and $C_0^{-1} C_1$ represents the long-run multiplier for the system. An inspection of the parameters estimated in the first step is very helpful in formulating the specification for the second step. However, in the process of re-formulating the problem second and third steps get blurred in practice. The third step involves decision to simplify (AB.20) or (AB.21) by deletion of variables that are not helpful in explaining the dependent variable. Hendry argues the final model must be useful. How the final model is derived is largely irrelevant; it is either useful or not, and that characteristic is independent of whether it comes purely from whimsy, some precise theory, or a very structured search (Hendry and Mizon 1985, cited in Pagan 1995:13). It is in this sense that some economists feel uncomfortable about this procedure.

The fourth step is considered the most important step in the whole process. During the process of specification search, routine examination of such items as the autocorrelation function, appropriateness of the functional form and recursive estimation of parameters is important. Residuals from the fitted model need to be checked for serial correlation, Heteroscedasticity, and normality.

It may be noted that if the fitted model satisfies the fourth step, which means the model is correctly specified and diagnostically sound, the disequilibrium error of the specification will be stationary. In that case, it would be free from spurious regression even if some of the variables in the regressors were non-stationary as they could be considered cointegrated with other variables. This advantage of the Hendry methodology makes it versatile in applications where the relevant variables are integrated of different orders, a commonly encountered problem in applied econometrics (Athukorala 1998). Studies such as Inder (1993), and Phillips and Loretan (1991) have demonstrated usefulness of GSM in such situations. ECM representation is particularly preferred as it has a first-differenced dependent variable, which is expected to be stationary for most time series variables and at the same time facilitates examination of short-term as well as long-term dynamics of the variables.

From the above discussion, it appears that the common practice of testing variables for time series properties such as unit root is by and large irrelevant for final modeling. In the case of smaller data sets, the unit root tests are not considered particularly effective anyway. However, it can still be argued that examination of time series properties is too important to be ignored. Particularly, if time series properties indicate a set of relevant variables are integrated of the same order then more sophisticated methods of testing cointegration and designing long-term relationships can be applied to separate out the long-term relationships from the short-term dynamics. The same is followed in this thesis as far as possible.

AB.5 COCHRANE-ORCUTT ITERATIVE METHOD

Cochrane-Orcutt (1949) Iterative procedure is specifically employed in Chapter 6 for simple regressions with adjustment for serial correlation. Let y be a $n\times 1$ vector of observations on the dependent variables, X $n\times k$ matrix of observations on the regressors including intercept term and U $n\times 1$ vector of disturbances. The Cochrane-Orcutt (CO) estimation method employs the iterative procedure to compute ML estimator of $y = X\beta + U$ under the assumption that the disturbances u_t, follow the AR(m) process (AB.22) with fixed initial values.

$$u_t = \sum_{i=1}^{m} \rho_i u_{t-i} + \varepsilon_t,\ \varepsilon_t \sim N(0,\sigma_\varepsilon^2),\ t = 1,2....,n \qquad \text{(AB.22)}$$

The procedure discussed in Pesaran and Pesaran (1997) and the software program Microfit 4.0 has been used for estimation. Some important points related to the estimation need to be noted. The CO method maximizes the likelihood function (which is equivalent to minimizing $\sum_{t=m+1}^{n} \varepsilon_t^2$) with respect to $(\beta',\sigma_\varepsilon^2,\rho')'$, $\rho = (\rho_1,\rho_2,..,\rho_m)'$ by iterative method of successive substitution involving two steps. In the first step the LL function is maximized with respect to β taking ρ as given and in the second step β is taken as given and the LL is maximized with respect to ρ. In each of the steps, OLS estimation solves the optimization problem.

The primary justification of treating initial value as fixed is asymptotic, and is plausible only when (AB.22) is stationary and n is large. Therefore, the program displays warning if the estimates of ρ_1, ρ_2, ..., ρ_m result in a non-stationary error process. In such a case, inferences based on the reported standard errors can be misleading. The estimated standard errors computed with this method are asymptotically valid even if the regression equation contains lagged values of the dependent variable.

AB.6 A NOTE ON DIAGNOSTIC AND OTHER TESTS

Almost all of the regression results in this study are tested for important time series properties of the residuals and the stability of the parameters. These tests are very important in their own right to ensure that the basic assumptions underlying the regressions are not severely violated. The Lagrange multiplier (LM) version of test statistics considered to be more stringent on the null hypothesis is used in most cases. However, in case of uncertainty, F-version of test statistics is also used in a few places. All tests are conducted using the software Microfit (Pesaran and Pesaran 1997).

Godfrey's test (Godfrey 1978a, 1978b), is used for testing *serial correlation* in residuals up to third order. In the case of regression with instrumental variables the serial correlation in residuals is tested using Sargan's statistics (Sargan 1976, Breusch and Godfrey 1981). Ramsey's RESET test (Ramsey 1969, 1970) using squares of the fitted values is employed to test the *function form*. The *normality* of the regression residual is tested using Jarque-Berra's test of normality (Jarque and Bera 1980, Bera and Jarque 1981). The residuals are also tested for *autoregressive conditional heteroscedasticity* (ARCH) up to third order in most cases using LM statistics as proposed in Engle (1982).

Predictive failure of the models is tested using second test discussed in Chow (1960), which also tests general specification error. The first test proposed in Chow (1960) is the usual test of the *stability* of regression coefficients. The *cumulative sum* (CUSUM) and *CUSUM of squares* tests based on recursive residuals described in Brown, et al. (1975) and Kalirajan (1995) have been employed to test the robustness of the regressions against structural breaks.

Wald test for parameter restrictions has extensively been used to test the causal relationship of explanatory variables as and when required.

In order to make comparison between competing models for explaining same dependent variable concept of non-nested tests for linear regression (Pesaran 1987, McAleer and Pesaran 1986) and model choice criteria such as the Akaike information criterion (AIC) based on Akaike (1973, 1974) and the Schwarz Bayesian criterion (SBC) based on Schwarz (1978) have been used. The non-nested tests include Cox's (1961, 1962) N-test, adjusted Cox test (NT test); Wald Type test (W-test) discussed in Godfrey and pesaran (1983); the J-test proposed in Davidson and MacKinnon (1981) based on an artificial OLS regression; the JA-test proposed in Fisher and McAleer (1981); the encompassing test proposed in Deaton (1982), Dastoor (1983), Gourierous, et al. (1982).

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