

A Short Term Liquidity Forecasting Model for India

Foreword

1. Introduction

1.1 The Concept of Liquidity

1.2 Liquidity Management

1.3 Liquidity Management and the Conduct of Monetary Policy

1.4 The Need for a Short-Term Liquidity Forecasting Model for India

2. Modeling of Liquidity Management: A Survey

2.1 Stages in Monetary Policy Transmission

2.2 Modeling Approaches

2.3 Liquidity Management and Assessment: International Experience

3. The Monetary Policy Framework and Operating Procedures in India: Implications for Liquidity Management

3.1 Monetary Policy Operating Procedures in India

3.2 Short-Term Stabilization of Financial Markets in India – Objectives and Policies

3.3 Operating Procedures and Implications for the Modeling of Liquidity

4. Analytical Framework for the Short-Term Liquidity Forecasting Model

Appendix I. Statement Showing Net Injection (+)/Absorption (-) of Liquidity

Appendix II. List of the Variables: Definitions

5. Performance of the Model

References

Annexure: The Modeling Team

FOREWORD

It is well recognized that, in market oriented economies, liquidity management forms a critical component in central bank operations. The need for better understanding of the implications of liquidity management through systematic methods of analysis based on models can hardly be over emphasized. However, such an endeavor is circumscribed by the availability of information and the extent of market developments. Needless to mention, while models can throw useful light on mechanisms of market behaviour, the inherent uncertainty requires that modeling efforts are undertaken with humility and a great degree of caution.

Against the backdrop of the reform process which placed accent of reforms on liberalization, greater openness and integration among various segments of the financial market and greater reliance on market mechanism to aid monetary policy operations, the Reserve Bank, in 1998, set up an Advisory Group of eminent economists comprising of Prof. D. M. Nachane and Prof. M.J.M.Rao of Bombay University, Prof. Vikas Chitre of Gokhale Institute of Politics and Economics, Prof. Indira Rajaraman of Institute of Economic Growth Prof. Mihir Rakshit of Investment Information and Credit Rating Agency Ltd. to guide the development of an operational model. Later, Prof. K. Krishnamurthy of Administrative Staff College of India was requested to join the Group. For assisting the Advisory Group, an inter-departmental team comprising of officials from Monetary Policy Department (MPD), Department of Economic Analysis and Policy (DEAP), Internal Debt Management Cell (IDMC), Department of External Investment and Operations (DEIO) and Dr. G. Nagaraju of National Institute of Bank Management was constituted. In its day to day work, the internal team was guided by Dr. D.V.S. Sastry, and Shri Deepak Mohanty, Advisers, MPD. Dr.Himanshu Joshi, Director, Dr. Kaushik Bhattacharya and Shri Jeevan Khundrakpam, Assistant Advisers attended to the work relating to model estimation and simulation.

The short-term liquidity forecasting model presented here is an outcome of the above modest efforts. The model makes use of high frequency(daily) data and explores the nature of interactions of financial markets with monetary policy instruments and is aimed at guiding short-term liquidity management operations of the Reserve Bank. The model blends financial modeling within the framework of a simple operational structure, without, however, compromising on the robustness of estimation. The theoretical inter play of different variables have been retained to the extent practicable while arriving at a recursive system.

In a dynamic system, as the underlying linkages are in a constant process of evolution, the empirical relationships also tend to change over time. This is more so in emerging markets like ours, which are in a transitional process. Efforts would, therefore, be made to review the model structure periodically, taking into account the experience gained in using the simulation results for day to day liquidity management as also expert opinions and comments.

Pursuant to the announcement made in the Statement on Monetary and Credit Policy for the year 2002-03, the model is being put on the Bank's website for wider public discussion and debate. Comments and suggestions on the model will be appreciated by the Bank, and they may be addressed to Adviser-in-Charge, Monetary Policy Department, Reserve Bank of India, Mumbai.

(Y. V. Reddy)
Deputy Governor
24-06-2002

CHAPTER 1

Introduction

1.1 The Concept of Liquidity

Although commonly used in monetary, banking and financial parlance, the term 'liquidity' is understood in different ways. In the macroeconomic context, it refers to overall monetary conditions, reflecting the extent of mismatch between demand and supply of overall monetary resources. In the context of financial markets, it is rather narrowly defined as the ease of undertaking transactions in financial assets at narrow bid-ask spreads.

For a central bank, the concept of liquidity is somewhat different. Entrusted with the responsibility of the regulation of the monetary system, liquidity for central banks refers to the monetary base (currency and reserves of the banking system), of which it is the solitary supplier. The supply of monetary base by the central bank depends on (i) the public's demand for currency, as determined by the size of monetary transactions and the opportunity cost of holding money and, (ii) the banking system's need for reserves to discharge payment obligations. In fulfilling these needs, central banks also attempt to control and modulate liquidity conditions by varying the supply of bank reserves to ensure smooth functioning and stability of financial markets. In the context of overall monetary policy, reserve requirements essentially play two important roles viz., smoothing short-term market interest rates and influencing the level of bank lending, deposit rates and the quantity of credit and deposits.¹ It is from this standpoint that a central bank may have to decide its reserve management strategy over a chosen time horizon to reflect its policy stance. From the operational angle, as bank reserves provide a cushion against money market disturbances, central banks may opt to design their reserve requirement policies differently such as, permitting averaging facility over the maintenance period and carrying over of reserve deficiencies to the next period or, in some cases, mandating bare minimum or even abolishing reserve requirements.

The importance of managing bank reserves evolves from central banks' ability to influence large markets by small operations by undertaking financial transactions which are fundamentally different from transactions undertaken by private market participants (Friedman, 2000). As a singular supplier of reserves, central bank transactions with market participants either increase or decrease the quantum of reserves held by the banking system, and are effective in moving financial markets and non-financial economic activity in a manner so desired. The reserve management function of a central bank is, hence, intimately related to the issue of taking decision on fixing the level of the interest rate in keeping with the goals of policy. This clearly implies that the central bank should be in a position to supply the amount of bank reserves demanded to attain the targeted operating rate. The setting of the targeted rate provides signals to the market participants to price other financial assets and eventually affect all non-financial activity in the economy.

1.2 Liquidity Management

Even though appearing rather simple, the complex nature of interrelationships among different markets in the financial system and the uncertainty in the behavior of financial markets, the task of liquidity management, to some extent, becomes difficult. Needless to mention, to achieve efficiency in liquidity management operations, central banks require to have some *a-priori* notion of the current and likely states of liquidity. Most central banks, therefore, attempt 'liquidity assessment' exercises based on collating information on several items of various accounts, transactions through which have a significant bearing on the outcomes in financial markets.

Often overlooked as less significant, assessment/ forecasting of short-term liquidity is indeed the most important function of any central bank operating in a market economy, essential both for sound management of monetary policy and ensuring smooth/orderly functioning of financial markets. The central bank's assurance of stable liquidity conditions through announcement assists in moderating uncertainties and help in reducing costs of liquidity management and settlement risks faced by market participants (IMF, 2000). Whereas dealing with mismatches in the demand and supply of liquidity on an ongoing basis forms the cornerstone of this function, liquidity management function also serves the task of steering the direction of the operating target (viz., the short-term interest rate) and, therefore, is germane for the purpose of guiding the evolution of the yield curve. As the central bank is the sole supplier of bank reserves, the assessment of liquidity begins by capturing the movements of the components/items of the balance sheet of a central bank with a view to estimating aggregate inflows and outflows and forming judgments about the prevailing or likely liquidity position. The exercise of this function is usually conducted in keeping with the overall objectives of monetary and financial policies. Liquidity assessment exercises and operations should also keep in view the implications for various prices/rates of returns in interrelated financial markets which determine the stability of the financial system and the broader long term goals of economic policy such as growth, employment and inflation.ⁱⁱ

1.3 Liquidity Management and the Conduct of Monetary Policy

The liquidity management function of a central bank involves an economy-wide perspective. Besides the management of reserves of the banking system, the central bank is concerned with the likely implications on its own balance sheet and that of other financial institutions.

Liquidity management by central banks can have short and long-term implications, depending on the nature of operations. While short-term effects are felt in financial markets, the long-term implications are, especially, relevant for the real sector which is influenced with long and variable lags. Short-term liquidity operations conducted by a central bank may not have immediate implications for the real sector, but injections or absorptions made over extended periods as an intended part of policy would have implications on output and prices through changes in interest rates and aggregate demand. Typically, the transmission effects of monetary policy decisions tend to differ across countries depending on country specific factors and institutional and regulatory frameworks.

Appropriate short-run monetary management is becoming an essential part of the overall objective of maintaining financial stability. Emphasizing on seven guiding principles for central banks, Mishkin (2000) cautions that serious economic downturns are associated with financial instability and that central banks have an important role to play. Among the many issues that need to be addressed in the context of financial instability is the concern with origin and transmission of different types of shocks in the financial system, the nature and the extent of feedback in policy and the effectiveness of different policy instruments as short-run tools of stabilization. Needless to mention, efficient short-term liquidity management is an essential part of this process and central banks, all over the world, therefore, closely monitor developments in different financial markets on continuous basis.

The management of liquidity in the short-run depends crucially on the operating procedures adopted by central banks. Given the economy specific characteristics, operating procedures and instruments tend to differ significantly among different countries, but a great deal of convergence in the approach, especially, increased emphasis on indirect instruments of policy, is discernible in the recent years.

As an initial step, liquidity management requires deciding on the appropriate level of the operating target, as part of overall strategy of monetary management. However, in doing so, the need for understanding the nature and the extent of interaction of policy instruments with the operating target and the extent of the stability of their relationship is of paramount concern. Operating targets are often reset and varied according to market movements, especially, when such movements are dominated by market frictions and expectations and not by economic fundamentals alone. In an economy with integrated financial markets and open structure, the pace of the movement of funds across markets and national boundaries poses considerable challenge to central banks in the area of liquidity management, especially, from the point of view of maintaining time consistency of monetary policy.

The stability of the relationship between the operating target and the intermediate target becomes important in the context of fundamental framework adopted for the conduct of monetary policy. For example, while in monetary targeting regimes, the stability and the predictability of the money multiplier is essential, in an interest rate targeting framework, it is the identification of the relationship between the short-term and the long-term interest rates which assumes importance. Establishing the relationship between the intermediate target and the goal of policy (such as minimizing the variance of inflation or output or a combined loss function) works as a guiding principle in the conduct of monetary policy.

1.4 The Need for a Short-Term Liquidity Forecasting Model for India

From a broader perspective, analytical models help in systematizing the thought process of policy makers, and provide a transparent setting for policy formulation. Formalizing the methods of policy making through models also enhance the effectiveness of central bank operations as they help improve financial markets' understanding of the conduct of monetary policy and in conditioning market expectations that are so critical for transmission of monetary policy. It is, therefore, necessary for the central banks to reveal great deal about

the methods, including, at least, the broad contours of forecasts, and the methods and internal models that they have historically done (Muller and Zelmer,1999; Blinder et al, 2001).

The present version is a simplified structural model of short-term liquidity assessment/forecasting based on information on financial transactions conducted by the Reserve Bank of India with the general government and other financial market entities.ⁱⁱⁱ Ever since market based reforms were initiated in India, financial markets have become closely interlinked and their operations relatively more complex. The easing of erstwhile regulatory controls and the dismantling of administered price mechanisms, the emergence of new products and services and arbitrage opportunities coupled with progression in the depth, volumes and liquidity of markets have resulted in substantial increase in market turnovers and faster movements of investment funds across markets. More notable is government securities market, in which average monthly turnover increased phenomenally from about Rs. 2,700 crore in 1995 to Rs 84,000 crore in 2001. The market activity in this segment has become increasingly interest sensitive with participants responding swiftly in treasury operations in keeping with changing considerations of risks and rewards. Similarly, in the forex market, market participants are quick in reallocating their portfolio with consideration for risks arising from likely movements in the exchange rate and liquidity conditions. As these market movements have prominently emerged in a deregulated system, financial sector reforms have, at the same time, provided more headroom for Reserve Bank to operate its monetary policy instruments for ensuring stability in financial markets. In its day-to-day liquidity management, the Reserve Bank relies increasingly on indirect instruments such as OMOs, though direct instruments such as the CRR or the Bank Rate are intermittently operated for market stabilization and for signaling the stance of monetary policy. In view of the growing integration of financial markets on the one hand, and the implications of liquidity management by the central bank on the other, market activities and monetary policy operations cannot be evaluated in isolation. It is, therefore, imperative that liquidity operations conducted by the central bank are assessed with an eye on both its effects on liquidity and the implications for rates/returns in different financial markets. It is from this standpoint that a mere evaluation of outflows or inflows or equivalently the approximation of net liquidity position on a day-to-day basis cannot suffice to guide intervention operations unless the systemic effects on financial markets are fully recognized.

The traditional framework for assessing liquidity is straightforward but information intensive and requires 'clear and efficient organization for accurate and timely forecasts (IMF, 2000). It requires pooling or 'centralizing of all relevant information that determine the future stance of liquidity without central bank activities' (IMF, 2000). The information required for doing this exercise depends on the timely availability of flows on a number of account heads; from those in the government sector whose accounts are maintained with the central bank to the latter's financial transactions with a host of other market participants such as banks and eligible dealers in government securities and foreign exchange, which are also entitled for central bank liquidity support. The list of participants essentially depends on the institutional and operational framework in each country and requires specific enumeration of the sources of liquid flows. In India, the Reserve Bank provides financing support to commercial banks and primary dealers both in the terms of standing liquidity

facilities and repos. Support to the central and state governments is made available in the form of Ways and Means Advances (WMA) in addition to subscription to central government securities through private placements when necessary. Since, by Statute, the Reserve Bank is the fiscal agent to central and state governments, the flows on account of redemption and issue of new securities also requires to be mapped for short-term liquidity assessment purposes. As the RBI undertakes financial transactions with market participants, in the securities and foreign exchange market, liquidity flows arising on account of these transactions would also need to be properly mapped. Finally, not the least, the assessment exercise is also dependent on a reasonable estimate of the changes in currency in circulation, which must be incorporated with net flows to determine the overall position.^{iv} In a simplified sense, aggregate liquidity assessment mechanism mirrors the movements in the stock of reserve money coterminous with changes in the items of its components and sources. While the statement on Reserve Money is an *ex post* accounting framework, the liquidity assessment exercise goes a step further, in making *ex ante* judgments of future liquidity needs and, therefore, has an element of forecastability. The liquidity assessment exercise of this nature is regularly undertaken by the Reserve Bank, and is an integral tool for policy making during the meeting sessions of the inter-departmental Financial Markets Committee (FMC). The magnitudes of most of the liquidity components required for the purpose are known to the Reserve Bank on a daily basis though some of the information may be obtained only after the operations are actually conducted during the day such as forex or OMO interventions depending on given circumstances. As the above discussion underscores, the task of liquidity assessment is not easy and requires considerable experience and expertise.

The weakness of the traditional approach of 'liquidity mapping' in dealing with some of the more immediate issues of policy relevance has prompted recourse to methods of empirical evaluation, such as, structural form modeling and time series based forecasting. Models cannot completely replace policy makers' informed judgments in the presence of complex market dynamics and unpredictable and quick shifts in market expectations and opportunities. They can, nevertheless, provide a formal analytical framework based on empirical regularities of inter-relationships that could be exploited to assist in decision-making through judicious pre and post facto evaluation of effects and consequences of liquidity operations. Needless to mention, the model development process is evolutionary, and must go side by side with the changes taking place in the financial system, such as, innovations in products and services, changes in institutional, legal, regulatory and operational frameworks and the effects of liberalization of the economy. The interest in, and the use of scientific criteria for liquidity assessment has increased in the recent years, and besides a number of papers on the issue, the Monetary and Exchange Affairs (MAE) Department of the International Monetary Fund (IMF) came out with an operational paper in November 2000 lending overall guidance to the efforts being made in this direction. This paper provides an unambiguous definition of 'liquidity' as synonymous with reserves of the banking system held with the central bank.

CHAPTER 2

Modeling of Liquidity Management : A Survey

2.1 Stages in Monetary Policy Transmission

The transmission effects of monetary policy are realized in stages. In the first stage, the monetary policy impulses provided by the central bank operations affect 'quantity' variables like bank reserves (alternatively, base money) or 'price' variables like short-term interest rates. Following changes in reserves or the short-term rates, an entire range of monetary and financial variables from monetary and credit aggregates to the term structure of interest rates and other related prices in financial markets, such as, exchange rates and asset prices are affected depending on to what extent these markets are interlinked. In the final stage, changes in the monetary and financial variables are reflected in changes in aggregate demand, working through factors, such as, income and wealth. The process of monetary transmission mechanism leading to effects on the real sector is theoretically well articulated (Mahadeva and Sinclair, 2001). Yet, it continues to remain one of the most extensively studied area in monetary economics, especially, from the point of view of the size and timing of different effects.

2.2 Modeling Approaches

A complete sketch of any model of transmission mechanism is difficult on account of several factors, such as, instability of economic relationships due to structural and institutional changes, expectations, etc. Attempts have been made to develop models of transmission mechanism as realistic as possible so as to enhance their utility in the context of policy analysis. Going by the different stages in monetary policy transmission process, models are built keeping in view of relevant time horizons for decision-making. At the initial level, as monetary policy impulses affect financial system rather promptly, a very short horizon model with high frequency data would perhaps be ideal for assessing the transmission effects across financial markets. However, since financial markets are often prone to reactions occurring due to feedback arising from expectations and news, it becomes imperative for the central bank to factor these effects while operating its policy. As it is not easy to model such complex interactions with full precision, a limited modeling of short-term interactions of monetary policy and financial markets requires taking a more focused approach such as empirical estimation of the effects of monetary policy measures on the operating target, namely, the short-term money market rate, and the subsequent effects on rates/returns in interrelated financial markets. Structural models have most often been complemented with advanced time series techniques such as autoregressive integrated moving average (ARIMA) or transfer functions for forecasting aggregate liquidity and its components. The success of these models in this area is yet to be established given the typically highly volatile nature of the information on liquidity flows and the poor range of autocorrelations in the data series (IMF, 2000).

2.3 Liquidity Management and Assessment – International Experience

Techniques for liquidity assessment have evolved over the years not only in the context of the developments in the theoretical literature on the subject, but also in keeping with the significant

changes in the *monetary policy operating procedures* in both industrial and emerging market countries. In the case of industrial countries, the focus of monetary policy operating procedures has increasingly been on interest rates, particularly at the shorter end (Borio, 1997). There has also been decline in reserve requirements, more active liquidity management, the use of flexible OMO-type operations as the main monetary policy tool and increasing transparency in policy signals regarding desired interest rate levels (Van't dack, 1999). Similarly, with the progressive liberalisation and integration of financial markets, a number of common trends have been identified in the monetary policy operating procedures of emerging market countries. First, there has been an increased market orientation of monetary policy instruments, with an emphasis on OMO-type operations. Second, there is an increased focus on interest rates rather than bank reserves in attempting to influence liquidity. Third, with increased market integration, central banks are now able to concentrate on the very short end of the yield curve, where their actions usually have the greatest impact. This trend is likely to be reinforced with the adoption of real time gross settlement (RTGS). Finally, there is increased recognition of the role of market psychology and expectations, which has an important bearing on central banking operations and the tactics of signaling.

Against this backdrop, this section provides a brief overview of the international practices in respect of liquidity management and forecasting by central banks. In general, central banks do not rely entirely on empirical models, but typically use a much wider range of other information and judgment while deciding to conduct monetary policy operations on a day-to-day basis. This is because, unanticipated shifts in the demand for liquidity are often driven by the market developments, such as, instability in forex or debt markets which is highly unpredictable. In order to mitigate tight liquid conditions on occasions, many central banks conduct more than one intra day cash injections through repos. Besides, there are also standby facilities available to banks to meet unexpected calls late during the day (Reserve Bank of Australia, 1998). Central banks also carry out fine-tuning and structural operations on *ad-hoc* or non-regular basis to steer interest rates, in particular, to smooth the effects on interest rates caused by unexpected liquidity fluctuations in the market.^y The provision of such facilities and actions taken by central banks is essentially a recognition of the critical role played by banks in completing settlement cycles and the funding risks faced by them. Technical advancements in the recent times, such as RTGS with the provision of intra-day repos, have allowed banks to have optimal liquidity management reducing the need to keep higher buffer in cash reserves to meet payment obligations, thus easing the central banks' difficulty in managing the system's actual liquidity needs. The true barometer of the effectiveness of central bank's market operations must be viewed from the point of view of maintaining stability in the short-term money market rate so as to enable banks to complete settlement at a cost that is close to the target overnight rate (Reserve Bank of Australia, 1998).

Despite the uncertainty in predicting liquidity conditions, econometric models could be used to provide first indicative forecasts, given the estimated structure of inter-relationships based on past information. In practice, there is a greater reliance on models by central banks that have explicit inflation objectives as, in such cases, it becomes even more important for policy makers to ensure that policy decisions are consistent with the inflation objectives and are as transparent as possible to the public.

A general practice in a liquidity assessment exercise is to obtain forecasts of different components of the central bank balance sheet in order to arrive at an estimate of liquidity that the central bank would need to inject (withdraw) into (from) the system so as to achieve its operating target (which could be a quantity or a rate target) and/or to generally preclude undue volatility in (short-term) interest rates. Conventionally, the sum of (1) Net Foreign Assets (NFA), (2) Net Position of Government (NPG), (3) 'Other items net' (all on the asset side of the balance sheet) *less* (4) Currency in Circulation (on the liability side) is taken as the 'Autonomous Liquidity Position' (ALP), since these are items which are beyond the control of the central bank in the very short-run. On the assets side, (5) the demand for bank reserves consists of the demand for required reserves (i.e. for fulfilling reserve requirements and meeting settlement obligations) and excess reserves. Accordingly, the Net Policy Position (NPP) is arrived at as the estimated demand for bank reserves *less* the estimated ALP. The issues involved in estimating/forecasting the different items as above is discussed below:

1. **Net Foreign Assets:** Changes in NFA occur as a result of central bank's interventions in the foreign exchange market. In the short-run, changes in capital flows could necessitate such interventions. Changes in capital flows, in turn, could result from a host of factors including interest rate differentials, exchange rate expectations and assessment of country risk. In practice, forecasting short-term capital flows is not a tractable exercise (IMF, 2000). Over the longer-term, identifying the determinants of the major components of the balance of payments (i.e. trade account, services balance, current and capital transfers, etc.) and aggregating these individual forecasts could be used to provide an estimate of the change in NFA. However, except for countries focusing on exchange rate commitments and at times of serious exchange market pressures, foreign exchange intervention is not the major source of variability in net liquidity. In addition, given the two-day settlement lag of foreign exchange transactions in most markets, the relevant information, so far as the liquidity impact is concerned, is normally available to the monetary authority.
2. **Net Position of the Government:** Changes in the net position of the Government would have a direct impact on overall bank liquidity if the government maintains its deposits with the central bank. The NPG is usually the most intractable item for forecasting (IMF, 2000). The NPG is reflected in the cash flows of government expenditures (current, capital, net lending and debt servicing) and receipts [tax and non-tax revenues, grants, external borrowings and domestic (non-central bank) borrowings]. Accurate forecast of the NPG would require quick and effective communication channels between the government and the central bank so that the latest available relevant information could be made available in order to generate forecasts. The general approach to forecast the NPG is to breakdown the annual expenditures and receipts into their components and to obtain their individual forecasts taking cognizance of the impact of macroeconomic variables, seasonal factors and observed regularities in budget execution/payment patterns. As far as (non-central bank) borrowings are concerned, obtaining forecasts is easier if the central bank is also the manager of government debt.
3. **Currency in Circulation:** This refers to notes and coins held outside the central bank. An increase (decrease) in currency demand reduces (increases) the availability of liquidity. In the short-run, the demand for currency is mainly affected by seasonal factors or exceptional events (such as retrospective pay increases), the patterns of which could be identified from historical data. Separate forecasts could also be obtained from the banking sector to

improve the central bank's forecasts. In the long run, the demand for currency depends upon select macroeconomic variables (e.g., GDP, interest rates etc.), and such forecasts could possibly facilitate identifying shifts in the demand function over time.

4. **The Demand for Bank Reserves:** The demand for reserves essentially stems from the obligation to fulfill reserve requirements and for meeting settlement obligations. Forecasting the demand for required reserves becomes non-trivial only when the reserve maintenance period is contemporaneous or partially lagged. Reserve requirements are typically stipulated in terms of a certain percentage of the bank's liabilities. A forecast of required reserves could be thus obtained from the forecasts of the underlying liabilities. The demand for excess reserves is a function of a number of factors viz., averaging provisions versus daily fulfillment of reserve requirements, length of the reserve maintenance period, cost of reserve shortfall and the eligibility of vault cash as a reserve asset. The Fed, for example, estimates the demand for excess reserves as a single equation model incorporating the following main explanatory variables: lagged values of excess reserves, overnight interest rates, dummy variables for bank holidays, and the amount of reserves banks are permitted to move between adjacent reserve periods. In general, averaging provisions tend to result in larger fluctuations in *ex ante* demand than daily fulfillment. In countries where reserve requirements are in place, central banks tend to match the main forecasting horizon with the maintenance period in order to obtain a measure of the cumulative impact of autonomous factors and of the baseline demand for bank reserves. In some countries (such as, the UK and Australia), without reserve requirements and averaging provisions, central banks forecast further ahead.
5. **Other Items, Net:** All other assets and liabilities barring (1), (2), (3) and bank reserves are included under this item. The major component which matters for liquidity forecasting purposes is the 'reserve float' which arises when the payer's and the payee's accounts with the central bank are not credited/debited on the same day. The problem of reserve float declines with the degree of sophistication and efficiency of the payments system. The best approach to forecast reserve float is to extrapolate historical data and assess the float's specific economic and non-economic determinants (tax and payroll dates and specific factors contributing to transportation delays).

In general, the main approaches to estimate the different components as discussed above are time series (atheoretical) models, structural models and judgmental estimations (in the face of insufficient data, instability in economic relationships and restructuring of the economy), adjusted for seasonal and calendar effects wherever relevant.

In the case of the **Fed**, the Trading Desk plans and carries out open market operations on a day-to-day basis in accordance with the Federal Open Market Committee's (FOMC) policy directive of a targeted federal funds rate. Accordingly, the Desk estimates the likely demand for total reserves by the banking system as well as the volume of non-borrowed reserves (NBR) that will be available to the banking system in the absence of any additional open market operations. Required reserves are estimated by forecasting transaction deposit behaviour and average reserve requirement ratios, incorporating the effect of technical and seasonal factors. Usually, the NBR path includes a standard allowance for excess reserves (US \$1 billion during 1991-1996). Generally, allowance for deviations from the standard amount are made informally, although occasionally, the recorded reserve path has been changed. From

the estimated demand for total reserves, the Desk subtracts the likely estimate of borrowed reserves (three types of collateralised credit - adjustment credit, seasonal credit and extended credit - made available to banks at the discount window) to form tentative NBR paths. The exercise is undertaken for the current and two subsequent maintenance periods. The NBR path is updated during a maintenance period with the revision in required reserves estimates. Informal revisions are also made when considered necessary.

The **Bank of Japan's** operating target for monetary policy is a specific level of the uncollateralised overnight call rate. The Bank conducts open market operations to adjust the amount of funds in the market with the objective of appropriately guiding the target interest rate. The funds to be adjusted through open market operations are the current account balances (CABs) of private financial institutions held at the Bank of Japan. The CABs include both required reserves and balances to meet payment and settlement needs. Daily fluctuations in exogenous factors such as flows in currency and treasury funds cause the overall level of CABs to change, necessitating appropriate market operations by the Bank in accordance with its operating target. This, in turn, necessitates a forecast of the changes in these exogenous factors. The forecast is made, at the first instance, for the medium term of about three months ahead, which is subsequently revised and refined for a month, week and a day ahead. The projection for the day is even revised many times. The medium-term projections are based on past patterns of CABs as well as the trends in economic and financial indicators. The Bank releases both the projected and actual figures (of currency, treasury funds and CAB surplus/shortage) on a monthly and daily basis in the form of the "Supply and Demand of Funds and Market Operations" table (the funds table). This is done with the objective of greater transparency and to stabilise the overnight call rate by causing the market participants' view of supply/demand for funds to converge. It may be mentioned that since March 2001, the Bank of Japan has switched from an interest target to a target for CABs. Although the target for CAB was increased substantially in August 2001 (from Y5 trillion to Y6 trillion), with the interest rates already at zero, the impact of the increase was considered to be largely psychological, reflecting the Bank's willingness to add excess reserves to the system.

The operational framework of the **Eurosystem** is based upon (i) reserve requirements, (ii) standing facilities (a marginal lending facility and a deposit facility) and (iii) open market operations, mainly conducted through repos. TARGET (Trans-European Real-Time Gross Settlement Express Transfer), comprising of the domestic RTGS of each European member state and a network of links between them and the ECB payments node (Gasper et al, 2001). The **ECB's** monetary policy strategy has the following salient features: (i) a precise definition of price stability; (ii) an analysis assigning a prominent role to money and (iii) a broad-based assessment based on a multiplicity of models and indicators.

The ECB does not have an official operating target for overnight rate (or any other type of inter-bank rate). The main refinancing operations (MRO), as part of the open market operations, equilibrate the demand and supply of funds by satisfying the demands for central bank balances in a smooth manner over the course of each maintenance period. This smooth functioning is complemented by the existence of a corridor on standing facilities, which not only signal the stance of monetary policy, but also provide and absorb liquidity overnight, and act as bounds to overnight market interest rates

The ECB decided to publish in June 2000 the estimated liquidity needs of the banking system coupled with the announcement of its weekly refinancing operations. The central bank attempts to provide liquidity through its open market operations, such that, after taking cognizance of its forecasts effects of autonomous liquidity factors, counterparties can fulfill their reserve requirements on average over the reserve maintenance period without systematic recourse to the standing facilities.

The **Bank of France** assesses bank liquidity by comparing the amount of central bank money held by credit institutions with the amount refinanced to meet their settlement and reserve requirements. The Bank of France resorts to two types of intervention in the money market: (i) using official rates (repurchase tenders and five to ten days repurchase agreements), which apply to the inter-bank market only and (ii) fine-tuning procedures designed to smoothen interest rates or adjust bank liquidity in the interval between two official interventions.

The **Bank of Mexico** recognizes that the use of monetary aggregates for the conduct of monetary policy has significantly declined in recent years owing to increasingly uncertain relationship between these aggregates and prices rendered by the decline in inflation. The Bank, however, publishes the forecast of the daily monetary base for the year with the objective of providing information which could facilitate evaluation of monetary policy. This forecast of the daily demand for monetary base is based on a model incorporating economic activity, interest rates, the lags in the dependent variable and a set of binary variables which attempt to capture seasonal effects.

It may be mentioned that Hamilton and Jorda (2000) introduced the **Autoregressive Conditional Hazard (ACH)** class of models which, *prima facie*, could be useful from the point of view of market participants but, nevertheless, offer interesting insights from a central banker's perspective at least as far as generating forecasts in the context of liquidity management is concerned. The ACH models can generate dynamic forecasts of the probability of a change in the target of the Federal Funds rate. Given a change in the target, an ordered probit model generates predictions of the magnitude by which the Fed would change the target rate. The motivation for this class of models is that conventional logit or probit models which assume that all relevant conditioning variables are included, are prone to significant serial correlation among the latent residuals. Similarly, Monte Carlo Markov Chain simulations and importance-sampling simulation estimators are also technically demanding. While, the Autoregressive Conditional Duration (ACD) model offers a simplification by specifying that the forecast of the length of time between events is a linear distributed lag on previous observed durations, it is not clear how such a forecast be updated on the basis of available information subsequent to the most recent target change. In this context, the ACH model indicates the likelihood of a change in the target in the next period, given all the information that is known in the current period. The advantage of the ACH model over the ACD model is thus, its ability to incorporate new information on other variables into the forecast.

Although concerned mainly with developed countries markets, especially, the United States, there is a large corpus of theoretical and empirical literature analyzing the role and operations

of central banks with regard to day-to-day liquidity management and the behavior of banks. The findings of some of the studies are presented below.

Spindt and Hoffmeister (1988) developed a model to study the micro-mechanics of the federal funds market and implications for day-of-the-week effects in the funds rate variability. They concluded that daily variability in federal funds rate increases towards the end of the settlement period and tends to be highest on the settlement day. Further, they also contended that in a continuous market, asynchronous trading, regulatory constraints, and accounting conventions had important bearing on the dynamics of trading activity and, hence, on the actual outturns of market prices.

In their study of the federal funds market, Griffiths and Winters (1995) found that, *ceteris paribus*, as the Federal Reserve intra-period and inter-period regulatory and accounting conventions gave financial institutions greater incentives to build accumulated reserve deficiency to build a surplus position, the lending pressure was higher than borrowing pressure on certain days of the maintenance period, especially, before non trading days and settlement days. They also noted that intra-day variances of the federal funds rate were higher in the afternoon and highest before non-trading days and settlement days. According to them the evidence points to the importance of institutional factors that can produce certain patterns in returns and variances in a highly efficient market of informed traders.

Hamilton (1996) studied the behaviour of the federal funds rate in terms of its time-series properties such as heteroskedasticity, seasonality etc. He argued that, theoretically, since the federal funds rate was expected to follow a martingale process, banks would be able to forecast the current rate based on the previous information. This is because, as the reserves held on any day of the reserve maintenance period are perfect substitutes for purposes of satisfying reserve requirements, the rate on a day should be equal to the rate that banks' funds-traders expect to hold the following day. Any expectations of higher or lower rate would be smoothed away with the arbitrage opportunities of the money dealers. The logical implication of this hypothesis was that even intervention made by the Federal Reserve through open market operations would be of limited use in influencing the daily federal funds rate.

With detailed time-series analysis of the daily federal funds rate, and plotting the series on a time scale, it was observed that there was typically higher volatility in the rate during Wednesdays, which happen to be the settlement day of the Federal Reserve requirements in the US. This indicated that the series had to be provided with 'day-of-the-week' effect to capture the heteroskedasticity. In the model that Hamilton subsequently built, it was found that days-of-the-week have special influences. For instance, Fridays typically showed lower rates as the two following days were holidays. Following this, Mondays showed slightly higher than average rate. Finally, it was noted that the rate usually fell during a typical reserve maintenance period, but surged during the settlement Wednesday. As the pattern essentially negated the federal funds rate being a martingale, Hamilton (1996) demonstrated that the Federal Reserve was, in fact, in a position to purposefully intervene in the market and influence the rate through open market operations.

Bartolini *et al* (2000a) studied banks' liquidity management and Federal Reserve official intervention policies in a setting that took explicit account of the main institutional features of the US federal funds market. They infer that the market's equilibrium was represented by a set of S-shaped relationships linking interest rates and bank reserves that showed high frequency heteroskedasticity of interest rates, essentially linked to the Fed's style of operations. In other words, interest rate volatility actually reflected the confidence of market participants in the commitment of the Federal Reserve in setting the interest rate target. Their analysis also confirmed that transparent targeting and the tendency to change targets only after FOMC meetings ever since 1994 were associated with less pronounced pattern of interest rate volatilities, and with lower volatility on and immediately before settlement days than in the pre-reform period.

Bartolini *et al* (2000b) use daily data on bank reserves and overnight interest rates and documented the fact that banks tend to hold more reserves during the last few days of each reserve maintenance period, when the opportunity cost of holding reserves is high. They suggest that uncertainty over reserve needs, particularly on settlement days, forces banks to hold unusually high reserves (even if the strategy entailed higher costs of carrying reserves overnight), unless impacted by a liquidity shock sufficiently large to justify the payment of the transaction cost (esp., penalties for overnight overdrafts). The accumulation of reserves near the end of the settlement period puts upward pressure on interest rates, which the Fed may or may not choose to smooth. Accordingly, the cyclical behaviour on the market's demand side is found mirrored by a similar cyclical behaviour of interest rates. The paper also makes mention of the role played by market imperfections and institutional features in creating constraints and frictions in the market, though a formal analysis of these factors was somewhat difficult to address.

Prati *et al* (2001), study the inter-bank markets for overnight loans of the G-7 and Euro Zone countries focusing on the behaviour of very short-term interest rates to the operating procedures of these central banks. They draw the following six lessons, (i) given the pattern of movements in overnight rates in different countries, prediction that rates should not display a systematic tendency to rise or fall between days in the same maintenance period is strongly rejected, implying that banks are unwilling to shift their demand for reserves across days to take advantage of systematic differences in opportunity cost of holding reserves, (ii) the settlement day tightness is a non-robust feature of reserve markets, explained by the differing styles of interventions (or differing inclinations to provide liquidity or not) of central banks around reserve settlement days rather than by trading costs or market frictions previously assumed to be more important, (iii) the high volatility on the settlement day is a robust finding that depends on the bank's inability to carry over reserve imbalances to future maintenance periods, resulting in scramble to fill or offload reserves causing bidding of inter bank rates up or down to optimize costs, (iv) settlement day volatility effects, when present, tend to spread to previous days owing to the market's previous perceptions about the commitment of the central bank to smooth interest rates, (v) lower required reserves are associated with weaker periodicity in interest rates, but no apparent effect on overall volatility and, (vi) patterns in interest rate volatility reflect the choice of intermediate policy targets, such that, higher volatility of overnight rates is associated with stronger exchange rate if the former is subordinated to the target pertaining to the latter. These six lessons bring out the fact that while the behaviour of

short-term interest rates could only be partly explained by market frictions, such as, transactions costs, credit rationing, bid ask spreads or periodic window dressing needs, it is, in fact, the differences in institutional details and central banking policies and procedures that play a major role in determining the realistic behavior of money markets.

Panigirtzoglou *et al* (2000), implement a reduced form model to study the divergences of short-term market rates from policy rates in three European countries (the UK, Italy and Germany) with different central bank operating procedures prior to the introduction of the Euro. One important finding reported for the UK was the increased ability of the Bank of England to steer short-term interest rates through its money market operations, especially after the introduction of gilt repos in 1996 and the introduction of two week gilt repos in 1997. According to them, these institutional changes helped in removing the constraints on banks' ability to arbitrage in the inter-bank market, increased the financing options available to banks and enhanced the pool of collateral available to the banks for obtaining funds from the Bank of England, all of which reduced the divergences in short-term market rates from the policy rate.

CHAPTER 3

The Monetary Policy Framework and Operating Procedures in India: Implications for Liquidity Management

3.1 Monetary Policy Operating Procedures in India

The economic and financial sector reforms of the 1990's were aimed at improving the efficiency in allocation of resources. The reforms process introduced many seminal changes in the regulatory, institutional and technological framework of the Indian financial sector. Reform of the monetary framework, deregulation of interest rates, market based exchange rate system, prudential norms and regulatory standards (such as, capital adequacy, provisioning and asset classification norms and asset liability and risk management standards) and relaxation of the regulatory regimen to facilitate decision making based on commercial considerations are some of the highly significant features that were instituted as a part of financial sector reforms. Withdrawing from its erstwhile developmental role, the Reserve Bank continued to play an active role in institutional, technological and market and product development areas to improve the efficiency and depth of financial markets. At the same time, the scope and techniques of the supervisory system were suitably strengthened in keeping with the changes occurring in the financial system.

In tune with the deregulation of the economy and as a part of reforms in the monetary policy framework, the operating procedures of monetary policy were suitably restructured, essentially by reducing reliance on direct instruments.^{vi} The operating framework in the present context, therefore, refers to the choice of operational target, the nature and frequency of market interventions, the use and width of a corridor for market interest rates and the manner of transmitting policy signals. This shift in the operating procedures of monetary policy is an outcome of the reorientation of the strategic objective necessitated by deregulation and liberalization of the financial markets and the increasing openness of the economy.

In the pre-reform period, prior to 1991, given the regulated and controlled nature of the economy, monetary policy operations were largely conditional on the government budgetary operations. The imbalances in the government budget were automatically monetised through the creation of *ad hoc* treasury bills leading to unabated expansion of the monetary base. The administered nature of the interest rate regime kept the yield of government securities at sub market rates and hindered the development of a vibrant secondary market. Coupled with high Cash Reserve Ratio (CRR), the Statutory Liquidity Ratio (SLR) provided a captive source of funds for the Government, which led to substantial preemption of resources. The lack of a liquid and deep secondary market in government securities precluded the possibility of carrying out monetary operations based on OMOs. Owing to this, direct monetary instruments like cash reserve ratio (CRR), selective credit control and interest rate regulation had to be employed to neutralize the monetary impact of budgetary deficits. During this period, and following the recommendations of the Chakravarty Committee (1985), bank reserves emerged as the principal operating target of policy.

In contrast, in the post reform period of the nineties, the operating procedures used for management of short-term liquidity are based on indirect or market-based operations. Consistent with the international practice, " the use of CRR as an instrument of monetary control has been de-emphasized and the liquidity management in India is increasingly undertaken through OMOs, both outright and repos" (Reddy, 1999). The transition from direct instruments to market based monetary operations was undertaken in steps with some of the very significant reforms made in the monetary policy framework during this period.

First, the yields on government securities were made market related by instituting auctioning procedures for public debt and treasury bills since 1992-93. As a result, the yields on government securities began reflecting market conditions and helped in developing liquidity and depth of the market. These institutional changes helped in reviving OMOs as an effective tool of monetary management. The RBI also facilitated in the process of the development of new market products such as repos, which were first introduced in December 1992, thereby helping market participants to optimize cash flows and asset allocations and to stabilize financial markets.

Second, the deregulation of lending (except credit upto and below Rs 2 lakhs) rate in October 1994 and deposit (except savings deposits) rate in October 1997 have enabled banks to gain freedom in setting rates according to commercial considerations and risk and reward perceptions.

Third, the automatic monetisation facility was replaced, in April 1997, by limit based Ways and Means Advances (WMA) to meet temporary mismatches in government receipts and expenditure. WMA have short-term liquidity impact on a day-to-day basis, but are strictly governed by assigned limits. In addition, limited formula based overdraft facilities are also available to central and state governments, the access to which is taken in case of net debit positions for a specified number of days. The abolition of automatic monetisation and the institution of WMA system has helped the RBI to reduce its recourse to CRR as an instrument of policy for mopping up excess liquidity flowing from budgetary or other causes, except for necessary considerations of arresting unwarranted disorderliness in segments of financial markets. Notwithstanding the reforms in the monetary policy framework, the persistence of high fiscal deficits continue to pose dilemma for monetary management requiring the Reserve Bank to balance the borrowing needs of the government against its impact on interest rate. In this context, the need for monetary fiscal coordination can hardly be overemphasized (Reddy, 1999).

Fourth, the RBI, in April 1997, rationalised its refinancing facilities by moving out from sector specific refinancing to general refinancing, thus allowing a greater liberty to market participants in sectoral allocation of resources. During this time, the Bank Rate was activated to make it as a reference rate and a signaling device. Accordingly, the interest rates on different types of accommodation from the RBI, including refinance, were linked to the Bank Rate. The activation of the Bank Rate endowed the RBI with an additional instrument (Reddy, 1999).

Fifth, the exchange rate regime was gradually deregulated and the exchange rate, under the terms of Article VIII agreement, was made market based in 1993 with full convertibility of

current account transactions. Currently, the exchange rate is determined by the supply and demand of foreign exchange in the market, with the Reserve Bank ensuring orderliness in the market by occasionally smoothing unanticipated mismatches and taking suitable measures to stem unwarranted speculation by means of interventions and other regulatory actions.

The deregulated regime of the nineties has helped in enhancing the scope of integration among various financial markets, thus improving the efficacy of transmission of signals across financial markets. At the same time, the efforts at improving institutional, regulatory and technological capabilities are helping in the task of meeting the challenges emerging from the growing complexities of financial markets. However, as deregulation and liberalization usually impart higher market volatility to financial markets, the need for RBI to have greater leverage over the liquidity is of utmost necessity. In the current milieu, it becomes necessary for RBI to change short-term priorities if so warranted by internal or external developments. This was clearly underscored in the Monetary and Credit Policy Statement of April 1998-99 which mentioned that instruments such as the Bank Rate, CRR, repo rates and access to refinance etc. would be subject to change at a short notice in the light of actual developments and emerging external market conditions. As an example, the Reserve Bank announced a package on August 20, 1998 including tightening of liquidity and a hike in repo rate in view of the disquieting developments in the foreign exchange market. The need to reinforce the role of the RBI in ensuring a smooth functioning of the financial system is hardly overemphasized. This requires creating more flexible and efficient mechanisms to impart interest rate signals by amending the existing legal provisions to enable the RBI to have greater operational freedom for the conduct of monetary policy. In this respect, the RBI has recently made proposals regarding certain amendments to the Government of India for consideration.

The successful introduction of LAF as a tool for managing short-term liquidity should be considered as a watershed in the evolution of the monetary policy framework in India. Following the recommendation of the Committee on Banking Sector Reforms (1998), to further develop the short-term money markets, the RBI introduced the Liquidity Adjustment Facility (LAF). Before the introduction of this facility, which has been implemented in phases, the RBI provided liquidity to the banks through its standing liquidity facilities, namely, as export and general refinance. Both these facilities were formula based and extended against eligible outstanding export credit and for meeting temporary liquidity mismatches, respectively. These refinance facilities, and also other different types of accommodation from RBI, were largely linked with the Bank Rate, which was reactivated in April 1997 as a reference rate for signaling the stance of monetary policy. The day-to-day liquidity management was aimed at achieving the overall monetary policy objective of price stability and ensuring adequate credit for growth.

The actual implementation of LAF began with the introduction of Interim Liquidity Adjustment Facility (ILAF) in April 1999. The existing general refinance was replaced by a system of Collateralised Lending Facility (CLF). Export credit refinance to banks was also brought under the ambit of this facility, and the primary dealers (PDs) were also provided liquidity support, called Level I support, by means of collateralized lending. These standing liquidity facilities were operated with formula based quantitative limits and were available at the Bank Rate. Additional Collateralized Lending Facility (ACLF) was also provided to the

banks and the PDs at two percentage points above the Bank Rate. Liquidity absorption, on the other hand, was done through fixed rate repo announced on a day to day basis, supplemented by OMO in government dated securities and treasury bills depending on the liquidity conditions. ILAF thus provided a mechanism by which liquidity is injected at various interest rates and absorbed at a fixed repo rate. An informal corridor of the call rate emerged with the Bank rate (refinance rate) as the ceiling and the repo rate as the floor rate, thereby minimizing the volatility in the money market.

The experience gained from the operation of ILAF led the RBI to implement a full-fledged LAF in three phases. The RBI intends to use the LAF to influence liquidity on a day-to-day basis and use it as an effective instrument for smoothening interest rates, rather than being a normal financing route for eligible instruments. It means elimination of CLF and ACLF in a phased manner to allow the operation of full effects of transmission channels through meeting day-to-day mismatches in liquidity on a discretionary basis. The first phase was introduced effective June 5, 2000, and with it, the ACLF to banks and PDs were replaced by variable reverse repo auctions.

In the second stage of LAF, the CLF was also to be replaced by variable reverse repo rate auctions. However, in order to facilitate a smooth transition, instead of eliminating the standing facility completely, it has been split into two parts viz., normal and backstop facility. The latter is intended to provide a cushion over the transition period. The normal facility constitutes about two thirds of the total quantum of standing facility provided in the form of CLF and export credit refinance and liquidity support to the PDs, and is at the Bank Rate. The remaining one-third is provided under the backstop facility at a variable daily rate linked to LAF auctions/National Stock Exchange-Mumbai-Inter-Bank Offer Rate (NSE-MIBOR). Liquidity absorption, which was effected through uniform price auction, has now been replaced by multiple price auctions.

In the final phase, LAF would operate at different timings of the same day with flexible quantum and rates depending on the immediate needs of the system, which would become feasible with the introduction of electronic transfer of funds and securities. There would be a movement away from sector specific refinancing, and the standing liquidity facility to banks and PDs would be withdrawn. Following recommendations made by Chakravarty Committee (1985), Vaghul Committee (1987) and Narasimham Committee (1991), the ultimate goal is to confine the access to inter bank call money market to banks only. The participation of non banks (FIs, mutual funds and insurance companies) would be restricted to repo market which would be facilitated by the operationalisation of Clearing Corporation of India Ltd. (CCIL). The operationalisation of Negotiated Dealing System (NDS) is a first step towards that.

3.2 Short-Term Stabilization of Financial Markets in India – Objectives and Policies

An inter-departmental Financial Markets Committee (FMC) has been in operation in the Bank since 1997. It monitors financial market developments on a daily basis. The committee monitors market developments with regard to call money rates, foreign exchange spot and forward rates, movements in volume of funds both in the money and foreign exchange markets, yield rates and volumes in government securities market and other relevant

developments in money and forex markets and banking and other monetary indicators. The committee makes quick assessment of the liquidity situation and recommends tactical operations for meeting the evolving situation in the financial markets. Besides market developments, the liquidity assessment made by the FMC depends on the evaluation of inflows and outflows from the Bank on a daily basis to arrive at an estimate of Net Injection / Absorption position on daily basis.

For convenience of analysis, the liquidity assessment exercise includes two distinct parts corresponding to daily Net Injection / Absorption. A pro-forma statement considered by the FMC for the purpose of liquidity assessment is presented in Annexure I. This statement on liquidity flows has been developed based on the experience that the FMC members have gained from their day-to-day operations.^{vii} The first part in the statement relates to the financial transactions carried out by the RBI with the Banking Sector, Financial Institutions (FI) and others and the second part concerns its operations with the Government Sector. Part one consists of Forex operations, Reverse Repos, Treasury Bills, LAF Repos and Reverse Repos, Coupon Payments, Cash Reserve, Refinance to Banks, Refinance to PDs, Issue or Redemption of Central Loans, Issue or Redemption of State Loans and Open Market Operations (OMO). The second part of the Statement consists of Government of India (GOI) Ways and Means Advances (WMA) and Overdrafts (ODs), Issue or Redemption of GOI Loans, Treasury Bills, Coupon Payment (GOI and States), State Governments WMA / OD and Issue or Redemption of State Loans. The Net Position is arrived at by combining the net injection or absorption in all these items of accounts, although in doing this exercise, some of the contra entries are offset fully or partially against each other, being credits and debits in RBI and Government accounts, respectively, such as, coupon payments and issue/redemption of government loans.

During a specific day, decisions on rates and quantities are taken by observing initial market movements which reflect the incoming news after the closure of the market in the previous day. Examples of such news could be the movements in other currency markets, flows of foreign capital and other remittances, evolving inter bank payments position, trading in securities and foreign exchange markets, credit flows, fiscal and trade position and the liquidity position as reflected by the reserves of the banking system and the bids made at the repo auctions. " However, the exact delineation of monetary policy transmission channels becomes difficult in the wake of uncertainties prevalent in the economic system, both in the sense of responsiveness of economic agents to monetary policy signals on the one hand, and the proper assessment by the monetary authority of the quantum and extent of desired policy measures on the other" (Reddy, 2002). From the policymaker's perspective, major financial markets such as the money market, government securities market and the foreign exchange market play a significant role. The capital market, though important, plays a somewhat exogenous role in this process although developments in this market are watched closely because of implications for payments system, which lies with the RBI.

Most of the information made available to the FMC by the staff of the Bank pertains to the previous day. These figures are obtained from the "books" of the Bank. So far as the expected movements of the components on the day of the meeting are concerned, majority of them (e.g., issues/redemption of treasury bills and government loans, coupon payments etc.) are known with certainty and in advance.^{viii} Some of the other components e.g., foreign exchange market

intervention, open market operations etc. are also known to the FMC in advance.^{ix} The instrument of LAF may, however, be viewed as an equilibrating mechanism for modulation of liquidity and setting of the operating target. Net liquidity injection or absorption under LAF thus reflects policy actions and the reaction of the Bank to the movements of financial markets on the day of the meeting. Accordingly, the liquidity operations on account of LAF on any particular day would depend upon the existing situation in the financial markets.

3.3 Operating Procedures and Implications for the Modeling of Liquidity

Ideally, good forecasts of some of these items of liquidity flows would make the policy making process somewhat easier. However, given the high frequency and the nature of the series, it would be extremely difficult to predict them. The time series properties of many of the items of liquidity flows would be random and close to white noise. Thus, at any point of time, only the latest position may throw some idea on its likely future movements but even that sometimes may not provide a 'good' estimate.

Incidentally, it may be noted that forecasts – even if obtained without errors – would make only the liquidity assessment table complete. However, the stability of financial markets would depend on many other factors like the interaction of the policy related measures with the market rates, the evolving activity in the economy that may produce dynamic liquidity needs, and not the least, sometimes swift changes in market sentiments and expectations. Good forecasts in this context are, therefore, a means and not an end in themselves. If the "end" is to maintain stability in the financial markets, it would be more useful to study the interaction of the market related rates with policy measures and prepare alternative scenarios. It may be noted that currently this is the approach adopted by the FMC.

From the policymakers' perspective, it is important to maintain stability in each of money, forex and government securities market. As financial sector reforms of the nineties have improved integration of the major financial markets, there is quicker translation of shocks from one market to the other. At the same time, since financial development in India is still an ongoing process, the reactions of certain markets such as the foreign exchange market which is thin could have potentially destabilizing effects that may be costly to address. This makes any monetary policy decision making in India somewhat complicated, requiring quick responses to emerging signs of instability. In this context, it becomes important to assess specific needs and to arrive at appropriate conclusions on whether the situation arose because of genuine demand-supply gap or due to build up of speculative tendencies. Accordingly, a careful review of the situation as a whole and assessment of needs for specific markets becomes very important.

In the current policy making process, policymakers have classified certain scenarios. The classifications are combinations of "abnormal" movements in one or more markets. Each classification demands a specific policy package. In actual reality this means either absorption or injection of liquidity in certain areas or relaxation or tightening of in certain policy related rates. The problem is, therefore, twofold. First, to assess whether the situation in any specific market is indeed "abnormal" due to speculative activities of market agents or that it reflects only a short-term demand-supply mismatch. The second is to decide upon the respective rates and quantities. To meet them successfully, the first needs a good informational network, and to meet the second, a clear understanding of the nature of interaction among the markets.

As it is well recognized that monetary policy decisions must be based on some idea of how decisions will affect the real world, there is need to conduct the policy within the framework of a model (Reddy, 2002). A short-term liquidity forecasting/assessment model accordingly could be of some help in understanding the interactions of the financial markets with monetary policy, and in developing alternative scenarios. Due to the highly volatile nature of the financial markets, the model can help in systematizing the process of thinking of the policymakers and help in assessing alternative scenarios. However, because of increasing role of market prices and complexities of markets in a globally interrelated financial world, it is necessary to approach the model building enterprise with great humility and a dose of skepticism, although ample justification for such modeling work certainly persists (Reddy, 2002).

In this context, it may be remembered that a model is like a mapping of a specific region. Depending upon the specific purpose and convenience, there could be alternative mappings. Similarly, depending upon the need of the day, there could be alternative models. Given the failure of most of the "big" models in the developed economies in predicting future movements, this is the approach currently adopted by many central banks.

This model covers a very short horizon viz., the daily operations of the Reserve Bank of India. As some of the major policy instruments like the CRR and/or the Bank Rate are not changed on a daily basis, the model treats them as given and focuses on other policy variables which involve the balance sheet operations and changes of repo and/or reverse repo rates. As the changes in CRR and Bank Rate could have medium term implications, it is felt that these impacts should be analyzed through separate models whose focus would be on medium to long-run implications of monetary policy actions.

CHAPTER 4

Analytical Framework for the Short-Term Liquidity Forecasting Model

The model developed for the purpose of short-term liquidity assessment consists of six equations and five identities. A liberal use of exogenous/predetermined variables is determined by choice, as most of these are known either completely or directionally to the policy makers. The model is also parsimoniously structured to serve the need for day-to-day assessment of the effects of the liquidity operations in financial markets.

In brief, the model addresses the interaction of RBI policy actions with the market rates. Accordingly, the net liquidity, which reflects in a change in the balance sheet of RBI, plays a crucial role in the model. It may be noted that net liquidity may be decomposed into three major parts. The first part consists of those components whose values are known with certainty during day-to-day policy operations, and thus, could be treated as completely exogenous. Second part consists of WMA whose movements are not known in advance, and attempt is made in the model to trace its movement through an equation. The third, and the final part, reflects the policy induced injection or absorption of liquidity. On a particular day, policy induced changes are incorporated conditional on the market movements and the movements in the two other major components of liquidity.

The liquidity modulating operations of the RBI has significant bearing on the reserve position of the banking system and, in turn, on the rates/returns in financial markets, that may be guided depending on policy preferences. For example, large OMO purchases can add to reserves and dampen call rates by adding reserves or liquidity to the system. The transmission of shocks may, however, not be the same in all the markets. For instance, liquidity expansions or addition to banking system reserves may have a strong effect in the forward exchange market, which may be predominantly driven in the short-run by changes (or expectations as captured by previous day change in exchange rate) in the exchange rate, rather than purely on domestic liquidity considerations.

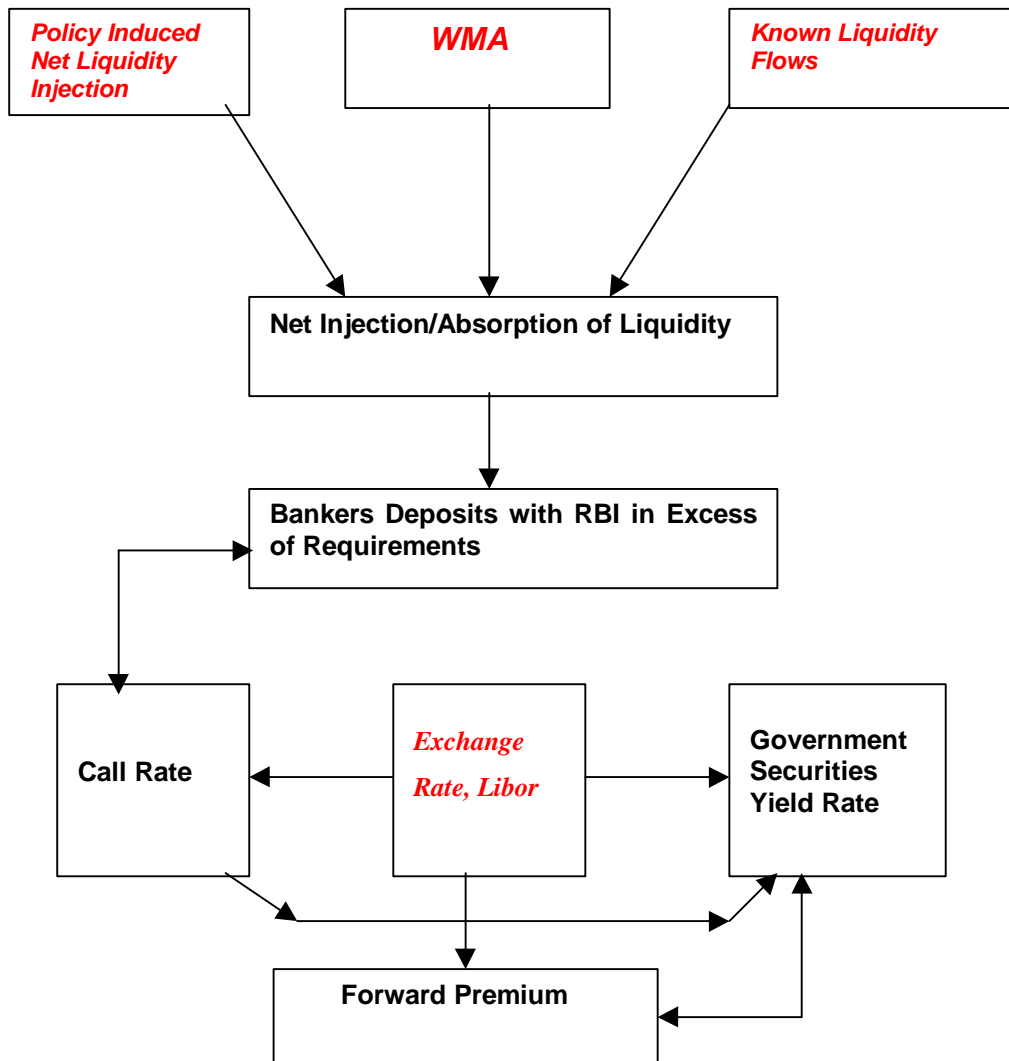
Despite the inherent feedbacks in the policy induced changes of liquidity on a given day, the model considers these components as exogenous, primarily because of the evolving nature of the Indian market which puts constraints on a clear policy rule. In this model we assume that net liquidity, as a whole, is a crucial determinant of excess reserves of the banking system. It is the accumulation of excess reserves within a fortnight that puts pressure on the money market rates. Thus, cumulative excess reserves within a fortnight is perceived as a crucial determinant of the call money rate in India. The other rates, like the yield rates of government securities, are assumed to be linked to the call rate. The structure of the model is depicted in a Flow Chart. The list of variables included in the model and their definitions are presented respectively in Appendices I and II at the end of this Chapter.

The brief structure of the model is follows: Equation 1 of the model explains the movement of the quantum of liquidity injected or absorbed through ways and means advances (WMA and

overdrafts) of central and state governments. Equation 2 captures the movements in liquidity as a result of banks holding of excess reserves (EXRES) with the Reserve Bank. Equation 3 models the evolution of weighted inter-bank money market rate (WTCALL). Equation 4 explains variation in one-month forward premium (IFP1M) in the foreign exchange market. Finally, Equations 5 and 6 determine yields on one (GYTM1) and five year (GYTM5) government securities, respectively, in the secondary market. The five identities for cumulative excess reserves (CEXRES), changes in the yield rate of government securities of residual maturity of one year (DGYTM1), balance for net liquidity position (NETLIQX), domestic-foreign interest rate differential (INTDIFF) and cumulative excess reserve ratio (CEXRR) are specified to complete the model.

A Flow Chart of the Liquidity Model

[Variables in *Italics* are Exogenous]



As it is obvious from the structure of the model, two equations namely, that of WMA, and WTCALL are wholly predetermined and technically do not come under the ambit of the model in the actual sense. It is interesting to note that not only did the sequential search for best specification produced these forms; by being outside the model they add value as a recursive tool of policy. Each of these equations perform quite reasonably in tracking the actual movements of the dependent variables, and also are good in producing *ex ante* forecast performances. Further, it need be mentioned that the model, apart from WMA flows, does not seek to explain any other items of liquidity, some of which, such as, LAF amounts, OMO and forex interventions are purely policy driven and are undertaken to modulate liquidity conditions depending on market developments and judgments made by the members of the FMC.^x Some others, such as, loan and treasury bill issues or redemptions or coupon payments are pre-known to the FMC. In particular, the basic focus of the model is on final net liquidity position which, as will be demonstrated later, drives the entire spectrum of financial market rates in the short term vide its influence on excess reserves positions held by banks with the Reserve Bank.^{xi} The detailed specification of equations is described below.

Equation 1 explains the net liquidity inflows or outflows on account of availing Ways and Means Advances (WMA and overdrafts) by central and state governments. Ways and Means Advances are assumed to depend on the issue/redemptions of central and state government loans (LOANTOT) and coupon payments (COUPON)- both of which amounts are known in advance, one day lagged daily net liquidity position of the government and five day of the month dummies.^{xii} The specification for WMA is:

$$(1) \quad \text{WMA} = f \{ \text{LOANTOT}, \text{COUPON}, \text{NETLIQ2}_{t-1}, \text{CWMA}_{t-11}, \text{d3}, \text{d4}, \text{d5}, \text{d10}, \text{d29} \}$$

Equation 2 explains daily excess reserves (EXRES) positions of banks over the fortnight. This variable tracks the pressure that banks could face over time given the need to maintain required reserves prescribed by the RBI. The variable is explained by current and lagged net liquidity positions (NETLIQX) obtained during the current fortnight, two lags of itself, a dummy (NF) representing the beginning of the new fortnight and the current flows on account of Ways and Means Advances. In addition, this equation includes one day lagged weighted call rate (WTCALL) to capture market expectations about liquidity developments. The specification of the equation for excess reserves is thus,

$$(2) \quad \text{EXRES1} = f \{ \text{NETLIQX}, \text{NETLIQX}_{t-1}, \text{NETLIQX}_{t-2}, \text{EXRES1}_{t-1}, \text{EXRES1}_{t-2}, \text{WMA}, \text{WTCALL}_{t-1}, \text{NF} \}$$

Equation 3 determines the weighted call money rate (WTCALL) based on the variation in its own lag, one day lags of the deviation of SBI call lending rate from weighted average call money rate (DCALLSBI) and cumulative excess reserves of the banking system as a proportion of total required reserves to be maintained in a fortnight (i.e., fourteen times the average required reserve for a single day of the fortnight). This variable has been referred as CEXRR. Thus, the specified equation is

$$(3) \quad \text{WTCALL} = f \{ \text{CEXRR}_{t-1}, \text{WTCALL}_{t-1}, \text{DCALLSBI}_{t-1} \}$$

Equation 4 below explains one-month forward premium rate (IFP1M) in the forex market based on two day lag of daily percentage changes in INR-USD spot rate (DINRUSD) (reflecting the periodicity of spot settlements) and the first lag of the forward premium itself. An important variable in the forward premium equation is the interest rate differential between the domestic and the foreign interest rate. The foreign interest rate in this study is proxied by LIBOR for US Dollar, while the secondary market yield rate of the government security for one year residual maturity was taken as a measure for domestic interest rate. The variable INTDIFF reflects the difference between the two rates. In the empirical specification, both the contemporaneous as well as the first lag of INTDIFF were included.

$$(4) \quad \text{IFP1M} = f\{\text{DINRUSD}_{t-2}, \text{INTDIFF}, \text{INTDIFF}_{t-1}, \text{IFP1M}_{t-1}\}$$

Equation 5 explains the evolution of the yield on government securities (GYTM1) with residual maturity of one year. The use of short end yield is on account of the short-term nature of the model where liquidity considerations become more important. The yield is explained by current weighted call rate (WTCALL), current and one day lagged IFP1M, one day lagged change in INR-USD dollar exchange rate (DINRUSD) and the first lag of the yield itself. The specified equation is

$$(5) \quad \text{GYTM1} = f\{\text{WTCALL}, \text{DINRUSD}_{t-1}, \text{IFP1M}, \text{IFP1M}_{t-1}, \text{GYTM1}_{t-1}\}$$

Equation 6 similarly explains the evolution of the yield on medium term five-year government security by a two-day lagged change in INR-USD (DINRUSD), the current change in the yield of one-year security (DGYTM1) and its own lag. Thus, the specification for GYTM5 is

$$(6) \quad \text{GYTM5} = f\{ \text{DINRUSD}_{t-2}, \text{DGYTM1}, \text{GYTM5}_{t-1} \}$$

The first identity extracts daily cumulative excess reserves (CEXRES) over the fortnight, given the information on daily excess reserves of banks on fortnightly basis. The second identity posits a transformation of the yield taken in the equations. The third identity adds up different components of daily liquidity flows arising from RBI transactions with market participants and the Government sector. The fourth identity is for the domestic-foreign interest rate differential and the final one is used to define the variable CEXRR as a ratio of cumulative excess reserves to total required reserves within a fortnight. All quantity data on liquidity used in the model are in terms of daily flows and the series, therefore, are highly volatile. In most cases the data show white noise properties and may be difficult, if not impossible, to be used for time series models such as ARIMA or its variants for reliable forecasting purposes.^{xiii}

Working of the Model

The model's operation is fairly straightforward, as all liquidity operations must eventually influence banking system reserves. For example, any positive or negative shock in LAFAMT, REF, WMA, OMO or others would have direct bearing on current NETLIQX position which, in turn, would determine the current level of EXRES. As EXRES and cumulative excess

reserves are derived, it enters the equations for market rates which evolve following such a reserve/liquidity shock. The complete model, in algebraic form, is presented in Box 1.

Box 1 : The Algebraic Structure of the Model

Equations :

- (1) $WMA = f \{ LOANTOT, COUPON, NETLIQ_{t-1}, CWMA_{t-1}, d3, d4, d5, d10, d29 \}$
- (2) $EXRES = f \{ NETLIQX, NETLIQX_{t-1}, NETLIQX_{t-2}, EXRES_{t-1}, EXRES_{t-2}, WMA, WTCALL_{t-1}, NF \}$
- (3) $WTCALL = f \{ CEXRR_{t-1}, WTCALL_{t-1}, DCALLSBI_{t-1} \}$
- (4) $IFP1M = f \{ DINRUSD_{t-2}, INTDIFF, INTDIFF_{t-1}, IFP1M_{t-1} \}$
- (5) $GYTM1 = f \{ WTCALL, DINRUSD_{t-1}, IFP1M, IFP1M_{t-1}, GYTM1_{t-1} \}$
- (6) $GYTM5 = f \{ DINRUSD_{t-2}, DGYTM1, GYTM5_{t-1} \}$

Identities :

- (1) $CEXRES = EXRES + (1 - NF) * CEXRES_{t-1}$
- (2) $DGYTM1 = GYTM1 - GYTM_{t-1}$
- (3) $NETLIQX = (FOREX + LAFAMT + BNKTBILL + COUPON + CASHBAL + REF + REDTOTAL + OMO) + (WMA + LOANTOT + GOITBILL + GOICOUP) + (EXRES - EXRES_{t-1})$
- (4) $INTDIFF = GYTM1 - LIBOR$
- (5) $CEXRR = CEXRES / (RR * 14)$

Appendix I
Statement Showing Net Injection (+)/Absorption (-) of Liquidity

	Pre-year	Current. Year	Pre- Fortnight (-2)	Pre- fortnight (-1)	Current Fortnight	Next two days	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BANKING SECTOR, FIs and OTHERS							
(a) FOREX Operations							
(b) Reverse Repos							
(c) Treasury Bills							
(d) Repos/Reserve repo (LAF)							
(e) Coupon payments							
(f) Cash Reserve							
(g) Refinance to Banks							
(h) Refinance to PDs							
(i) Issue/Redemption of Central loans							
(j) Issue /Redemption of State loans							
(k) OMO sales/purchases							
Net Position (1)							
GENERAL GOVERNMENT SECTOR							
(a) GOI WMA/OD*							
(b) Issue/Redemption of GOI loans							
(c) Treasury Bills							
(d) Coupon Payment							

(GOI and States)
(e) State Govt
WMA/OD*
(f) Issue/Redemption
of /State Loans
Net Position (2)
Final Position (1+2)
Currency in
Circulation

Appendix II

List of the Variables: Definitions

(Data Frequency : Daily)

Sr. No.	Name	Definition
1.	FOREX	Net Forex Operations during the Current Day [Item (a) in Banking Sector, FIs and Others in Appendix I]
2.	BNKTBILL	Treasury Bills during the Current Day (RBI (A/c)) [Item (c) in Banking Sector, FIs and Others in Appendix I]
3.	LAFAMT	Net LAF Amount from Repo and Reverse Repo during the Current Day (issue / redemption RBI A/c) [Sum of Items (b) and (d) in Banking Sector, FIs and Others in Appendix I]
4.	COUPON	Coupon Payments during the Current Day (RBI A/c) [Item (e) in Banking Sector, FIs and Others in Appendix I]
5.	CASHBAL	Cash Reserves of banks with RBI during the Current Day [Item (f) in Banking Sector, FIs and Others in Appendix I]
6.	REF	Net Refinance to Banks and Primary Dealers during Current Day [Sum of Items (g) and (h) in Banking Sector, FIs and Others in Appendix I]
7.	REDTOTAL	Issues/Redemption of Central and State Loans during the Current Day (RBI A/c) [Sum of Items (i) and (j) in Banking Sector, FIs and Others in Appendix I].
8.	OMO	Net OMO Sales/Purchases during the Current Day [Item (k) in Banking Sector, FIs and Others in Appendix I]
9.	WMA	Combined WMA to Central and State Governments [Sum of Items

		(a) and (e) in the General Government Sector of Appendix I]
10.	LOANTOT	Issues/Redemptions of Government of India and State Loans during the Current Day [Sum of Items (b) and (f) in the General Government Sector of Appendix I]
11.	GOITBILL	Treasury Bills issued during the Current Day (Govt. A/c) [Item (c) in the General Government Sector of Appendix I]
12.	GOICOUP	Coupon Payments of GoI and States during the Current Day (Govt. A/c) [Item (d) in the General Government Sector of Appendix I]
13.	NETLIQ2	Liquidity Injection(+) / Absorption (–) to the General Government Sector [Sum of all Items from (a) to (f) in the General Government Sector of Appendix I]
14.	NETLIQX	Final Net Liquidity Position for the Current Day
15.	RR	Required reserves to be maintained during the current fortnight
16.	EXRES	Excess Reserves with the banking system during the current day
17.	CEXRES	Cumulative Excess Reserves During the Day of each Fortnight
18.	CEXRR	Ratio of Cumulative Excess Reserves as a Proportion of Total Reserve Requirement for the Current Fortnight
19.	WTCALL	Weighted Average of Call Rate (Borrowing)
20.	GYTM1 GYTM5	Secondary Market Yield Rate of Government Securities with Residual Maturity of One Year and five years respectively.
21.	DGYTM1 DGYTM5	Change in GYTM1 and GYTM5, respectively.
22.	DINRUSD	Change in Spot INR-USD Exchange Rate (Closing)
23.	IFP1M	Forward premium for One Month
24.	DCALLSBI	Daily difference between State Bank of India lending in Call Market and the weighted call borrowing rate.
25.	CWMA	Cumulative WMA in a Fortnight
26.	LIBOR	London Inter-Bank Offer Rate for US Dollar
27.	INTDIFF	Difference between GYTM1 and LIBOR for US Dollar
28.	NF	Dummy for the First Working Day of a New Fortnight

29.	D3, D4, D5, D10, D29	Dummies for Specific Days of a Month, D_i being the i -th Day of the Month. For example, D_4 is the fourth day of a month.
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Note : Units for 'quantity' variables are denominated in Rs. Crore while those pertaining to rates refer to percentage per annum.

CHAPTER 5

Performance of the Model

The sample of the daily data used in this study covers the period from May 2, 2001 to March 2, 2002 including a total of 248 observations. The series pertaining to liquidity flows showed a high degree of variation, and some of the series like OMO also revealed the presence of sharp spikes. Such sharp jumps were also visible in other market variables. Most of the items of liquidity flows under different heads were found to have zero mean. In case of a few series that had non-zero mean, the absolute values of the means were, however, small compared to the standard deviation. Similarly, medians pertaining to all liquidity flow series were also either zero or near zero.

While most of the series displayed high volatility, they also appeared to be somewhat asymmetric, with long tails. Most of the series were found to be leptokurtic and were characterized by large values on either side of their averages. As a consequence, for most of the series Jarque-Bera tests rejected normality. It may be noted that in daily data, such observations with long tails are not uncommon.

So far as modeling is concerned, the presence of outliers and the deviations from normality created significant problems. The deviations from normality might be due to several factors. These deviations could take place due to expectational factors, or due to institutional or policy induced factors. Typically, the first could occur because of frictions or lack of integration in specific markets. Deviations of second type could occur when to meet the long-run objective, the central bank intervenes in specific market decisively on specific days. It may be noted that while there may be sound underlying logic behind these operations, such logic would be difficult to explain when the focus of the model is on the very short-run. Thus, an "abnormal" policy shock in a day might, in fact, appear to be "normal" over a longer frame when interactions of average movements of different series are considered over a longer horizon. As the focus of the current model is on the short-run, the model should not be used to analyze the interactions of this type of shocks with market variables.

For most of the "flow" variables, autocorrelations and partial autocorrelations were small and correlations beyond lag three were generally not significant. The data also indicated moderate autocorrelations and partial autocorrelations for some "flow" variables between lags 10 to 15. Such autocorrelations could occur because of the beginning of a new fortnight and due to other institutional factors as reflected by "days of a fortnight effect" in a few series. The autocorrelation structures of the "rate" variables, on the other hand, displayed typical patterns that closely resembled an AR(1) process. An examination of the contemporaneous correlations among variables revealed that although some of the individual correlations were high, correlations, in general, were low except in case of contra-entries.

All the variables were subjected to rigorous unit root tests. The results revealed that most of the liquidity flows – individuals as well as aggregates – could be considered as I(0) series. Market variables, on the other hand, revealed a mixed pattern. The tests revealed clear evidence of stationarity of the call money rates series, while for the forward premium series (one month)

the evidence was not that firm. The secondary market yield rates on government securities considered in this study, on the other hand, appeared to be non-stationary. Similarly, while variable like INR-USD spot exchange rate appeared to have unit root, first difference of the log did not.

So far as the detailed empirical specifications of the equations are concerned, the approach adopted in this study was somewhat iterative in nature within the broad framework depicted in the flow chart. Diagnostic checks of the residuals in the initial specifications helped to identify some lacunae that were subsequently removed by adding or deleting variables in the equations at specific lags. To the extent possible, inclusions of these lags were made to justify the operational aspects.

The equations were estimated individually through ordinary least squares (OLS) technique. All the estimated relationships were subjected to rigorous diagnostic checks that involved examinations of the first four moments, percentiles and autocorrelations and partial autocorrelations of the residuals. The results revealed that the residuals fairly approximated white noise. However, in many cases, the residuals were found to be leptokurtic, implying the prevalence of occasional large shocks. The contemporaneous correlations among the residuals were also examined and found to be low, implying estimation by more sophisticated techniques like SUR might not lead to significant gains in efficiency.

The estimated relationships were also subjected to rigorous stability tests. In particular, wherever appropriate, the test suggested by Hansen (1992) was used for that purpose.^{xiv} The results established that the estimated relationships were, in general, stable. In a few cases, however, some individual parameters – in particular, the residual variances in a few equations – showed evidences of instability. It may be noted that besides structural change, sometimes presence of non-linearity in a series could lead to instability of the estimated parameters in a linear regression framework. The non-linearity could be due to institutional, expectational or some other factors.

It may be noted that although Hansen's test could be applied to examine the stability of any individual or subset of parameters, in practice more weight is placed on the value of the joint statistic pertaining to the stability of the estimated equation as a whole. The variable lags through which one financial series affects another may often render the estimated lag coefficients unstable. Also, when there are many explanatory variables, instability in only one or two estimated parameters may not be considered as a serious misspecification of the equation if the joint statistic reveals stability of the equation as a whole (Hansen, 1992).

The estimated equations with identities were grouped together and simulated using a static simulating routine with Gauss Seidel iteration.^{xv} The use of the static simulation method was considered more relevant because of the short-term nature of the model, which assumes that market reactions are driven by information that is of relatively short horizon.

The model was estimated for the first two hundred observations and the rest of the observations (viz., 48) were used recursively for one-day and two-days ahead ex ante or out of sample forecasts. The in-sample fits appeared to be reasonable. The results establish that cumulative excess reserves of the banking sector to be a crucial determinant of the money market rates.

The liquidity operations of RBI, on the other hand, were found to influence reserve formation significantly. RBI policy actions, thus, appear to be a crucial factor behind the stability of the short-term money market rates.

Out-of-sample performance for the rate variables also appeared to be within a tolerable limit. For example, the mean absolute errors (MAE) for both one and two days ahead forecast of call money rate were about 12 basis points. Similarly, MAE for the yields of government securities were placed at 5-6 basis points for both one and two step ahead forecast, while for forward premium, it was higher at about 15 basis points. It may be mentioned that while Theil U coefficients for one-step ahead forecast for a few series were greater than or near unity, the Theil U coefficients for "rate" variables were generally between 0.8 and 1.0, consistent with the international benchmark.

Besides forecasts, the model could be used to construct scenarios for policy purposes. For example, reversing Equation 3, for a targeted call money market rate, the cumulative excess reserve that, on an average, keeps the call money market at that level could be obtained. Once a figure for cumulative excess reserves is arrived at, using Identity 1, the corresponding excess reserves could also be solved. Using the Equation 2, one can then obtain the corresponding net liquidity position (NETLIQX). Finally, using Identity 3, along with the forecasts of WMA from Equation 1 and other known liquidity components, one can arrive at the total policy induced liquidity that is likely to keep call money rate at the targeted level. In this process, for different targeted call money rates, the corresponding policy induced projections could be arrived at.

References

- Andrews D. W. K, and W. Ploberger, 1994** : 'Optimal Tests when a Nuisance Parameter is Not Present Only under the Alternative', *Econometrica*, **62**, 1383 – 1414.
- Bartolini L., G. Bertola and A. Prati, 2000a** : 'Banks' Reserve Management, Transaction Costs, and the Timing of Federal Reserve Intervention', *International Monetary Fund Working Paper No. WP/00/163*.
- Bartolini L., G. Bertola and A. Prati, 2000b** : 'Day-to-Day Monetary Policy and the Volatility of the Federal Funds Interest Rate', *International Monetary Fund Working Paper No. WP/00/206*.
- Blinder A., P. Hildebrand, D. Lipton and C. Wyplosz, 2001** : 'How do Central Banks Talk?', *ICMB/CEPR Conference, Geneva, May 4, 2001*.
- Borio C. E. V., 1997** : 'The Implementation of Monetary Policy in Industrial Countries : A Survey', *BIS Economic Papers, No. 47*.
- Friedman B., 2000** : 'The Role of Interest Rates in Federal Reserve Policy Making' *NBER, Working Paper, 8047*.
- Gaspar V., G. Perez-Quiros and J. Sicilia, 2001** : 'The ECB Monetary Policy Strategy and the Money Market', *International Journal of Finance and Economics*, **6**.
- Goodfriend M., 1987** : 'Interest Rate Smoothing and Price Level Trend-Stationarity', *Journal of Monetary Economics*, **19**, 335–348.
- Goodfriend M., 1991** : 'Interest Rates and the Conduct of Monetary Policy', *Carnegie-Rochester Conference Series on Public Policy*, **34**, 7–30.
- Goodhart C., 1999** : 'Central Bankers and Uncertainty', *Bank of England Quarterly Bulletin*, February, 102–114 (Reprint of a speech at the annual Keynes Lecture, British Academy, London, October 1998).
- Griffiths M. D. and D. B. Winters, 1995** : 'Day-of-the-week Effects in Federal Funds Rates : Further Empirical Findings', *Journal of Banking & Finance*, **19**, 1265–1284.
- Hamilton J. D., 1996** : 'The Daily Market for Federal Funds', *Journal of Political Economy*, **104**, 26–56.
- Hamilton J. D. and O. Jorda, 2000** : 'A Model for the Federal Funds Rate Target', *NBER Working Paper No.7847*.
- Hansen B. E., 1992** : 'Testing for Parameter Instability in Linear Models', *Journal of Policy Modeling*, **14**, 517–533.
- International Monetary Fund, 2000** : 'Liquidity Forecasting', *Monetary and Exchange Affairs Department Operational Paper, MAE OP/00/7*.
- Mahadeva L. and P. Sinclair, 2001 [Ed.]** : *The Transmission Mechanism of Monetary Policy*, Mimeo, Centre for Central Banking Studies, Bank of England.
- Mishkin F.S., 2000** : 'What Should Central Banks Do?', *Federal Reserve Bank of St. Louis Review*, November/December, 1–13.
- Muller P. and M. Zelmer, 1999** : 'Greater Transparency in Monetary Policy : Impact on Financial Markets', *Bank of Canada Technical Report No. 86*.
- Panigirtzoglou N., J. Proudman and J. Spicer, 2000** : 'Persistence and Volatility in Short-Term Interest Rates', *Bank of England Working Paper*.
- Prati A., L. Bartolini and G. Bertola, 2001** : 'The Overnight Interbank Market: Evidence from the G-7 and the Euro Zone', Federal Reserve Bank of New York , July.

(<http://www.ny.frb.org/staff-rp/2001.html>)

Quandt R. E., 1960 : 'Tests of the Hypothesis that a Linear Regression System Obeys Two Separate Regimes', *Journal of the American Statistical Association*, **55**, 324 – 330.

Reddy Y. V., 1999a : 'Monetary Policy Operating Procedures in India', in *Monetary Policy Operating Procedures in Emerging Market Economies* by the Bank for International Settlements [Ed.], pp. 99–109.

Reddy Y. V., 1999b : 'Monetary Policy in India: Objectives, Instruments, Operating Procedures and Dilemmas', *Speech given at the Fourth Securities Industry Summit, Organized by Invest India Pvt. Ltd., Mumbai, May 26, 1999.*

Reddy Y. V., 2002 : 'Parameters of Monetary Policy in India', *Reserve Bank of India Bulletin*, **LVI**, 95–110.

Reserve Bank of Australia, 1998 : 'Reserve Bank Domestic Operations under RTGS', *Reserve Bank of Australia Bulletin*, November, 54–59.

Reserve Bank of India : Annual Reports of Different Years.

Reserve Bank of India, 1985 : Report of the Committee to Review the Working of the Monetary System, *Reserve Bank of India*. (Popularly known as Chakravarty Committee)

Reserve Bank of India, 1987 : Report of the Working Group on the Money Market, *Reserve Bank of India*. (Popularly known as Vaghul Committee)

Reserve Bank of India, 1991 : Report of the Committee on the Financial System, *Reserve Bank of India*. (Popularly known as Narasimham Committee I)

Reserve Bank of India, 1998: *Report of the Working Group on Money Supply : Analytics and Methodology of Compilation*, Reserve Bank of India. (Popularly known as Reddy Committee)

Spindt P. A. and J. R. Hoffmeister, 1988 : 'The Micromechanics of the Federal Funds Market : Implications for the Day-of-the-Week Effects in Funds rate Variability', *Journal of Financial and Quantitative Analysis*, **23**, 401–416.

Van't dack J., 1999 : 'Implementing Monetary Policy in Emerging Market Economies: An Overview of Issues' in *Monetary Policy Operating Procedures in Emerging Market Economies* by the Bank for International Settlements [Ed.], pp. 3–73.

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- i. These effects follow from the two distinguishing ‘money’ and ‘credit’ views of monetary policy transmission. In terms of the money view, as the central bank shrinks supply of reserves, households and firms compete to hold the now reduced supply of money and, hence, drive up the interest rate as they attempt to sell securities for money. As per credit view, as the supply of reserves is reduced, banks are forced to cut back their lending, causing the interest rate in the loan market to clear only at a higher interest rate.
 - ii. In a broader sense, the interest rate instrument that the central bank chooses to implement its monetary policy must be set at a level that is appropriate for attaining the goals of policy. And the most straightforward way to do so is to study the historical data to estimate its relationships with variables that correspond to the ultimate objective and to adjust the policy instrument suitably.
 - iii. Market entities comprise mainly deposit taking banks, primary dealers in government securities, authorized foreign exchange dealers.
 - iv. As per Reserve Bank accounts, the adjustments of currency chest withdrawals/deposits are adjusted with respective balances of banks with the RBI and, hence, the net position on account of currency is already reflected in balances of banks. Further, it may be assumed that as the RBI carries out the overall liquidity adjustment, any demand or surplus of currency is accommodated by its liquidity operations carried out during the day. It is because of this, as we demonstrate, that the net final position tracks excess reserves very closely.
 - v. Goodfriend (1987,1991) suggests that interest rate smoothing by central banks helps in protecting the financial sector against crises from sudden jumps in interest rates and in communicating their policies more clearly to the financial markets. Goodhart (1999) argues that interest rate smoothing makes the future path of short-term interest rates (and hence the long-term rates as well) more predictable and thereby helps in improving policy effectiveness.
 - vi. The utility of the indirect instruments of monetary policy was underscored by the Third Working Group on Money Supply (Chairman Dr. Y. V. Reddy, 1998) suggesting that output response to policy operating through the interest rate was gaining strength.
 - vii. The current pro-forma statement is a considerably refined version of the method adopted for liquidity assessment exercise that was initiated in the Reserve Bank in 1997.
 - viii. Treasury bills are auctioned on the basis of pre-known calendar. Beginning April 2002, the calendar for auction of dated Government securities would be implemented.
 - ix. In case of foreign exchange market intervention , the liquidity impact is felt two days after the intervention because of the time taken for actual settlement. Similarly, OMOs are generally decided a few days in advance.
 - x. Equations for these items in the balance sheet could nevertheless be attempted and kept as backup equations. The use of these equations for getting independent estimates of liquidity items is substantiated by the low degree of cross, auto and partial correlations among the residual series.
 - xi. The central idea is to provide an estimate of net liquidity policy position that is consistent with desirable rates/returns in financial markets and leave the allocation among different items to the FMC. In many instances the RBI may be undertaking forward looking interventions to correct the course of the

monetary policy or to give direction to market expectations or for smoothing liquidity conditions in the system or other relevant factors, such as, the size and concentration of financing needs, the time expired since last intervention and prospects for reversal of rates to within desirable bands.

- xii. NETLIQ2 is defined as the sum of inflows/outflows on account of the government comprising of WMA, loan issues and redemptions, and treasury bills.
- xiii. Preliminary efforts at developing ARIMA and Transfer Function models were made by the internal team but these did not provide any reasonable results.
- xiv. Hansen's test has a score test interpretation. Apart from the power consideration, this test can be used for testing stability of individual parameters (i.e., intercept, slope or variance), some subset of the parameters or even for the complete set of parameters jointly. Also this test procedure does not require any arbitrary specification of the trimming region as required in 'Mean F' of Andrews and Ploberger (1994) or in 'Sup F' of Quandt (1960) test for $I(0)$ variables.
- xv. It may be noted that the specified system has two exogenous equations (WMA and WTCALL), and therefore, their graphs compare actual to fitted values in static simulation.