

**MONEY DEMAND STABILITY MYTH OR REALITY  
AN ECONOMETRIC ANALYSIS**

R. R. Arif

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## **MONEY DEMAND STABILITY :MYTH OR REALITY -AN ECONOMETRIC ANALYSIS**

**R. R. Arif \***

### **Introduction**

A developing economy is often vulnerable to fluctuations in growth and inflation, both significant factors related to the demand for money. Changes in money supply, whether policy induced or not, also have a bearing on this relationship. The current transition towards deregulation and market-related rates has raised doubts about the traditional wisdom regarding the role of money demand in the formulation of monetary policy. This study examines this influential, yet highly controversial subject in monetary economics - namely, the behaviour of aggregate money demand. The crucial question is whether economic agents adjust to exogenous shocks and whether such shocks have a bearing on the stability of the money demand relationship. Furthermore, it is necessary to examine whether money demand in India is stable enough to be useful for *ex-ante* prediction and control.

There has been considerable research on this topic in India. But there is not much empirical evidence based on the newer techniques such as cointegration. Thus a comparative evaluation of the various tools of applied economic research as applied to money demand analysis remained a long felt need. A major objective of this study is to make a contribution towards this end.

Based upon alternate theories and models, we investigate money demand behaviour in India from the 'sixties to the 'nineties. In addition to the partial adjustment specification commonly adopted in conventional applied research, we employ the buffer stock approach and the technique of error correction. Having obtained different empirical models, we evaluate them, focussing on stability and predictability - issues that have important implications for monetary management.

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\* Smt R. R. Arif is a consultant based in Mumbai. The views expressed in this study are the author's own and do not necessarily reflect those of the Reserve Bank of India.

## **Monetary Management and Inflation**

The major concerns of monetary policy are inflation control, management of interest rates and exchange rate stabilisation. Insofar as price stability is concerned, targeting money supply growth is a critical element of policy. Since a serious mismatch between money demand and supply could have destabilising effects on the economy, it is essential to obtain the best possible forecast of money demand in order to set a realistic target of money supply.

The targeting procedure practiced in India is a somewhat flexible “feedback” rule for money growth based on nominal income, price movements, fiscal constraints and commercial credit demand. The monetary authorities have sought to do so via four policy instruments—administered interest rates, fixing reserve ratios, a system of credit controls and managing the exchange rate. Open market operations have seldom been prominent instruments of policy in the past.

## **Policy in a Changing Environment**

In recent years, the economic landscape in India has fundamentally altered. Not only could this affect the amount of money and other forms of wealth that people hold, but also the conduct of monetary policy. In the developed countries, the unpredictability of money demand had caused great concern throughout the seventies and eighties. The widespread changes that occurred in their financial sectors accentuated the failure of conventional monetary tools to control domestic inflation or even to predict interest rate changes due to a given policy. Similar misgivings are now being voiced about the role of monetary policy in India.

On theoretical grounds the question is whether in an evolving environment, a stable money demand relationship could exist at all. From the operational angle the problem is regarding the choice of targets (base money or money stock) and the impact of a specific policy prescription (eg: will tight monetary policy adversely affect,

investment and real output?). The critical concern is the efficacy of monetary management in controlling inflation<sup>1</sup>.

These issues need to be discussed with reference to the debate on rules versus discretion. The very existence of a number of stands of thought - the Keynesian , the monetary, the rational expectations, and the new Keynesian shows that despite better econometric tools and fresh empirical evidence from rapidly changing global conditions, the debate has not ended.

### **Organisation of the Paper**

The rest of the paper is organised as follows : Section 1 discusses theoretical and empirical issues in money demand analysis and provides the framework for the study. Section 2 examines the factors that have affected money demand behaviour in India in the last three decades. Various empirical methods to ‘improve’ the estimated function under the partial adjustment specification are covered. In Section 3 the focus is on short run dynamics. Having examined the problem through conventional methods, attention shifts to disequilibrium analysis. A major dissimilarity between the two is the concept of equilibrium and modeling the transmission process. The econometric techniques used in the latter are also quite different.

Section 4 makes a comparison of the three classes of dynamic models estimated in the study: partial adjustment equations (PA models), those based on the concept of the buffer stock of money (BS Models) and error correction (EC Models). The empirical evidence is reviewed to assess the stability and predictability of money demand in India. Section 5 summarises the findings and their implications for monetary policy.

## Section 1

### Analytical Issues

The literature on money demand has a long and rich tradition of theoretical and empirical research, often guided by schools of thought that have different and at times, conflicting views on the impact of various factors on the individuals desire to hold real cash balance. An extensive survey of this vast subject is beyond the scope of this paper. In what follows we attempt a brief review of the issues that are significant from the standpoint of empirical research.

### Alternate Theories

The classical quantity theory as given by the equation  $MV = PT$  as formulated by Irving Fisher was based on the assumptions of a constant velocity of circulation and people's desire to hold money to cover their transactional needs. This equation between the demand for money and money income  $M/P = f(Y)$ , is in the tradition of Pigou who has been called the great inventor of the static equilibrium. In the classical theory, there is no reference to the interest rate.

The familiar Keynesian distinction between the transactional, precautionary and speculative motives for demand for money raised a whole gamut of issues relating to the influence of interest rates on money demand. Keynes (1936) postulated that the former two components of demand are associated with the needs of the people to meet their current payments and receipts proxied by income ( $Y$ ), whereas people's speculative demand is influenced by their expectations ( $r^*$ ) about the rate of return on alternative assets ( $r$ ). The relationship could be specified as the following money demand function.

$$M/P = k Y + f(r-r^*, r^*)$$

This model formalizes the influence of the expected real rate of return on money demand. Clearly, the most important contribution of Keynes (1936)

to money demand analysis is the emphasis on the interest rate.

In the sixties and seventies, large neo-Keynesian St Louis type of macroeconomic models extended the basic relationship between money, output and prices, retaining the money demand function at its core. Such models, some involving more than a hundred variables, were developed for India as well<sup>2</sup>. On the other hand, Baumol(1952) and Tobin(1956) looked at the choice-making behaviour of a firm's asset demand functions such that

$$MT_d = \frac{1}{2} \sqrt{\frac{2bY}{R}}$$

The model states that an economic agent's demand for transactional balances is determined not only by current transactions Y, but also by the interest rate (R) and the brokerage cost (b) of converting assets to cash. In practice, however, it is difficult to isolate the purely transactional component from the rest. As an alternative explanation to money demand behaviour, the microtheoretic approach provides an illuminating exposition. Miller and Orr had followed the Transaction theory and modelled money demand where in uncertainty appears as an element requiring larger precautionary balances.

Individuals make economic decisions not only about how much to consume and invest, but also about holding their wealth in the form of money and other assets. When individual decisions are pooled the behaviour of aggregate money demand emerges. Concerned with a portfolio of assets, of which money is one, a typical asset equilibrium model would contain various interest rates. If one is studying narrow money which has mostly a transactional component, short term interest rates are relevant. Long term returns apply in the analysis of speculative money demand. At the aggregate level the inventory theoretic approach implies a function of the type

$$M/P = f(R, \delta) W \quad R < 0, \delta > 0$$

W is non-human wealth; R and δ depict respectively the return and risk

associated with bonds (assets). Price uncertainty is a measure of risk aversion. Its positive sign postulates that the higher the risk, the lesser is the desire to hold bonds. But unlike the highly developed economies, uncertainty may prompt a household especially in India, to switch not from bonds to money, but from precautionary money to tangible assets - commodities, gold and real estate. The application of these ideas to money demand in India has received scant empirical attention<sup>3</sup>, primarily due to the paucity of data.

The most basic tenet of monetarism - namely "There is a stable relationship between money and income. One increases when the other does" - deserves attention, not the least because it has influenced economists whether they subscribed to it or not. The original quantity theory of a rigid and unchanging ratio between money stock and prices is probably too simplistic to represent the complex behaviour of the Indian economy. The restated theory is that money yields a flow of services and is a substitute for all other assets.

$$M/P = f( R_e, R_b, P_X, W, h )$$

This model embodies a number of ideas:(i) Money holdings are adapted to permanent magnitudes. (ii) Measured income is sensitive to changes in money stock. (iii) Substantial changes in prices or nominal income are almost invariably the result of changes in nominal money supply. (iv) Several interest rates affect aggregate demand.

Whatever the theory, it is universally believed that the scale of economic activity and the opportunity cost are the basic determinants of money demand. The models that stress the transactional aspect explain money demand in terms of current income, the cost factor and consequences of delays in converting near-monies to cash. The inventory theoretic models focus on the speculative motive to analyse the micro-behaviour of economic agents as an allocative problem based on risk and returns in a portfolio of assets versus zero income and riskless cash. Milton Friedman (1969) believed that wealth, rather than current income is the scale variable, with the return on bonds and equities exerting negative influences in the money demand function. The Keynesian approach requires not only the real interest rate but also the fiscal interactions to

be part of the specification.

### **Short Run Dynamics and Monetary Expansion**

There is more or less a consensus on the nature of money demand in the long run - a relationship in levels. The controversy is regarding short run demand behaviour. The nature of exogenous shocks, the formation of expectations and the dynamics in the transmission process have been extensively analysed. The selection of the appropriate tools is as important as the theoretical considerations. The Phillips curve, and the IS-LM paradigm have been employed to analyse the consequence of disturbances to the economic system. Laidler(1985) and others have used the latter, to provide illuminating insights on money demand analysis. In recent years, more rigorous econometric tools such as cointegration and error correction have come into vogue. Before discussing them, we quickly review what the different theories have to say about short run dynamics and monetary expansion - an issue that has grave implications for monetary policy.

In Keynesian analysis, interest rates adjust to match money demand with the new level of money supply. This adjustment will affect real economic activity. If interest elasticity is low and adjustment is gradual, then the transmission process slows down, but the end result is the same: higher money supply lowers interest rates and raises output so that money demand attains its long run equilibrium level. Hence Keynesians favour a discretionary monetary policy and injections of liquidity to stimulate economic growth. This theory may not be wholly relevant when interest rates are administered. As interest rate deregulation gathers momentum, and the rates reflect market conditions, the Keynesian theory could be tested.

Monetarists and neo-classical economists both agree that when a money supply shock pushes demand off its long run path, only the price level adjusts to move it back to equilibrium. But where the process of adjustment is concerned, the two schools differ. The monetarist view as in Friedman and Schwartz is that there could be a long and variable lag between the cause and the ultimate effect. If prices are sticky, which is more than likely

in a world of imperfect markets, the adjustments will occur slowly and therefore equilibrium would be attained over a long period. The Fisher effect, combined with rational expectations suggests that monetary expansion leads to a fully perceived change in inflation and a concomitant adjustment in nominal interest rates. The policy prescription is a long run monetary growth target.

Consider the Lucasian world, where there is complete knowledge of the past and every economic agent acts rationally. Since expectations are rational, the adjustments to systematic changes are instantaneous. An important contribution of the rational expectations school, also referred to as the neo-classical approach is the distinction made between the anticipated and unanticipated components of a change in money supply<sup>4</sup>. According to it, any anticipated money supply increase is immediately neutralised by a price rise to achieve instantaneous equilibrium without any real effects (structural neutrality). Consequently if people foresee a policy change - say, a fixed rate of monetary expansion - it will have no real effect; only an unforeseen increase in money supply can affect output. But by and large, price adjustments maintain equilibrium. If we assume that full information is available to all players who then proceed to make rational decisions, then almost the entire money supply growth will be anticipated. Thus the Rational Expectation and Structural Neutrality hypothesis<sup>5</sup> combined with the Lucas Critique that a policy change also changes the structural parameters, leaves hardly any room for monetary management. It strongly recommends a non-interventionist monetary policy.

The buffer stock theory also distinguishes between the two kinds of money supply growth. But it offers a novel interpretation to the impact of unanticipated shocks and a different perspective to the process of adjustment. When we compare the neo-classical concepts with the Buffer Stock Approach (BSA), a major point of dissimilarity is in the analysis of the transmission mechanism. The former assumes instant adjustments. According to BSA, the change takes time to work through the system. Hence the transmission mechanism is most important to the analysis. Initially disequilibrium in the money market is resolved by changes in

the stock of real balances, which act as a temporary residual buffer till people reallocate their asset portfolio. The concept of money as buffer stock is not new. Artis and Lewis(1976) had first reasoned that when money supply is exogenous and expands faster than the rate at which money demand could adjust, it results in ‘disequilibrium money’.

Till recently all money demand models subsumed that actual money stock will ultimately equal the desired balances. The difference of opinion among economists was regarding the equilibrating variables, the process of adjustment, the time lags, the appropriate specification and methods of estimation. In any case, the underlying theory was based on the concept of equilibrium. But in the disequilibrium theory this fundamental concept itself is being questioned. As in conventional specifications, the hypothesis here is that there is an underlying long run, stable relationship between the demand for real balances and the major factors (output, interest rates etc.) that affect it. The crucial difference is in the interpretation given to departures from long run equilibrium.

Suppose for some reason, the response of variables to a money supply shock is sluggish. Then actual and desired money holdings will not be equal even after several time periods. Since such shocks to the system occur repeatedly, the money market will remain in perpetual disequilibrium. This leads to the proposition that the demand for money is continually fluctuating around its long run equilibrium path. Consider, for example, an unexpected increase in money supply. It may not instantly induce a large enough decline in interest rates to accommodate the excess money supply which chases goods, services and assets. Interest rates move down and output is also affected. In due course prices rise high enough to accommodate the monetary expansion; and the economy moves towards its steady state. But before the adjustments are completed, the next money supply change occurs - and the cycle is repeated.

As regards the policy implications, the BSA transcends the polarisation implicit in the Keynesian and monetarist descriptions of how money supply growth affects the economy. The hypothesis is that prices adjust to anticipated changes in money; but unanticipated changes are held in precautionary portfolios. A larger component of the former implies that the Monetary Authority has the ability to systematically influence monetary expansion; interest rates will not overshoot and stable prices can be maintained. If this is indeed how the monetary transmission mechanism works, then money supply shocks will cause less interest rate fluctuations than is generally believed. Depending on the speeds of adjustment, sooner or later, prices will rise as a consequence of large doses of monetary expansion. Notice that the above concepts are radically different from the traditional equilibrium analysis.<sup>6</sup>. If this theory is true, some form of error correction is required to model money demand.

### **Buffer Stock Models**

In the 80's, these notions led to the development of disequilibrium models of various kinds. Among them, perhaps the best known is the Shock Absorber model of Carr and Darby(1981) which extended the Chow mechanism to include two important influences:(i) unexpected changes in money supply and (ii) unexpected changes in income (YS).

$$m_t = md_t + (1 - \alpha)m_{t-1} + a_1(m - m^*)_t + a_2 YS_t + U_t$$

$$md_t = r_0 + r_1 YP_t + r_2 R_t$$

Here  $md$  is the steady state money demand function and  $m^*$  is anticipated money supply. Under the null, the coefficient of the money supply shock will be positive and significant. The Carr-Darby model was questioned on two counts. The first objection is simultaneity: the money supply shock variable and the error term are correlated and hence the estimates are biased. Coats(1982) has suggested that the hypothesis of 'partly exogenous' money supply

can overcome this problem. The second objection is that the insignificance of anticipated money supply cannot be assumed, but needs to be tested. MacKinnon and Milbourne(1984) used the following model to prove their point.

$$m_t - p_t = a_0 X_t + a_1(m_t - m_t^*) + a_2 m_t^* + U_t$$

They found that both components of money supply had significant coefficients. Carr and Darby refuted their claim. A lively debate went on in the latter half of the 80's. The BSA has many supporters, who believe that it offers convincing rationale to explain short run money demand response to money supply shocks.

Empirical models have been developed in many countries to validate the BS hypothesis. A crucial question is the estimation of anticipated money supply<sup>7</sup>. The shock component (MUN) is derived from the following identity

$$MS = M^* + MUN$$

Estimated under perfect foresight,  $M^*$  would be the closest to the systematic component of money supply. But in practice, there is no perfect foresight. Goldfeld and Sichell (1990) hold that it is overly restrictive to assume that only past values of money supply are relevant in the estimation of anticipated money supply. They also include other past information such as short-run interest rates, the multiplier and so on. Muscatelli (1989) compares forward and backward-looking models and is inclined towards the latter. Cuthbertson and Taylor (1990) have experimented with alternate mechanisms to generate expectations in empirical BS models, including forward-looking models where people's expectations about future output and interest rates determine their current behaviour. They conclude that non-rational expectations of money supply changes throw up better empirical results in the BS model. Cuthbertson (1988) finds that BS models with forward-looking expectations do not perform better than those which estimate  $M^*$  through a standard AR process.

An error correction (EC) mechanism is implicit in the buffer stock approach. In a BS model, a temporary buffer absorbs the unanticipated money supply shock. In the general class of EC models, the corrective mechanism for all random disturbances is estimated through cointegration methods. A recent study by Lastrapes and Selgin (1995) sheds light on these distinctions and finds that buffer stock money is quantitatively important in determining real balances in the short run.

### EC Models

The basic concept of error correction is to make adjustments for deviations from the steady state through a dynamic process wherein the disturbances are stationary. In conventional empirical work, the consequences of non-stationarity in the data series could be profound. One could end up with spurious regressions which render the estimated parameters and tests of significance as questionable. A well-known statistical solution is that prior to any multi-variate analysis, the data are pre-whitened by detrending or differencing.<sup>8</sup> But the apprehension remained that the process of pre-whitening might obliterate useful information on the long run characteristics of the variables under observation. Sargan(1964) and many others had considered a mechanism to retain such variables in levels, provided the model residuals were white noise. The concept of cointegrated series and the seminal work of Engle and Granger(1987) reconciled the two approaches. What emerged was the EC mechanism which allows one to estimate the equation in levels and link it to the dynamic relationship. Whether one postulates a BS model or an EC model, the principle is the same - jointly modeling short and long run influences on money demand. This, perhaps, is the most attractive feature of disequilibrium models.

Cointegration states the following: Suppose that two time-series (say, money stock and prices) have a tendency to move together in a similar pattern in the long run - even if they react differently to the same stimuli in the short run. Then, given certain mathematical characteristics such

as integration of the same order, the variables are said to be cointegrated. Finding cointegrated series is important because such series have several useful properties. For our purpose, the main advantage is that if money is co-integrated with income and interest rates, it is possible to model the short run demand for money much more accurately by embodying an error correction mechanism in its functional specification. Moreover, cointegration of two or more variables itself is a valid indication of long run stability.

Prior to searching for cointegration among a set of variables, one must ensure that the series are of the same order of integration. For this, it is customary to rely on unit root tests applied to each variable in the data set. Consider the following process<sup>9</sup>.

$$Y_t = \beta_0 + \beta_1 t + (\alpha - 1) Y_{t-1} + u_t$$

In this data generating process, if  $y$  has a unit root ( $\alpha = 1$ ), then it is an I(1) process. Having done so and obtained a cointegrating relationship, we estimate the dynamic EC equation. The objective is to reduce a model of the following type to a parsimonious form.

$$m_t = \alpha + \beta L(X) - r EC_{t-1} + \varepsilon_t$$

where  $L$  is the general lag operator,  $X$  is a set of exogenous variables and  $EC$  is the error correction term which provides the vital link between the static and dynamic money demand relationship. In the reduced form of the equation, the variables will be in differences, with significant lags and the errors will be white noise.

In the last 10 years, there has been an explosion of research in the applied methods of cointegration analysis. The concern centres on detecting and eliminating serial correlation, tests for unit roots and the distribution of estimators involving I(1) series. As the literature shows, there are many variations in model specification and estimation methods. None of them is free from difficulties. Engle and Granger's original two-stage procedure is

easy to apply. But it has its limitations in finite samples, particularly if  $R^2$  is low in the cointegrating regression, as pointed out by Banerjee et al(1986). The general to specific strategy advocated by Hendry(1987) lets the data determine the model in a single step. But it has its critics <sup>10</sup>. The generalised maximum likelihood procedure of Johnson and Juselius(1990) is a full-system approach. The VAR method allows restrictions to be imposed on the coefficients and offers a gain in degrees of freedom. Subsequently Engle and Yoo(1991) have also proposed a three-step estimation procedure. These newer econometric tools are applicable to any quantitative study involving time series. Thomas (1993) cites some examples of the disequilibrium approach specifically used in money demand analysis.

When cointegration analysis - initially developed for bivariate models - was extended to the multivariate case, an immediate complication was the possibility of discovering multiple cointegrating vectors and then selecting one of them. The question of causality is important here. Obtaining a parsimonious equation is another thorny issue, often resolved by assigning constraints or priors.

An empirical difficulty in India is that techniques such as VAR, impulse response and variance decomposition require long monthly or quarterly observations. In small samples, the standard assumptions may be violated and hence the inferences may not be applicable<sup>11</sup>. This *caveat* needs to be considered while interpreting the results of the EC models.

## The Central Question

Central to the research in money demand is the issue of stability. What constitutes stability and under what conditions does it hold? The most comprehensive method is to apply the 3-P criteria for stability : Precision, Parsimony and Predictability .

Precision: Obtaining precise and reliable estimates of the parameters (elasticities and speeds of adjustment) in the money demand function

is the first criterion for evaluating the model. The income elasticity is expected to be positive and that of opportunity cost, negative. Therefore one looks for significant, meaningful values for the parameters and their constancy. A structural ‘break’ which can be captured by a ratchet variable or a dummy does not necessarily constitute instability in money demand.

Parsimony: A parsimonious model has few arguments with plausible links to the real economy. The empirical model must be statistically good enough for the estimates and their confidence intervals to be meaningful. Problems of bias, auto-correlation, multicollinearity and heteroskedasticity if present, must be eliminated. In particular, the residuals should not be time-dependent.

Predictability: The ability to predict money demand is the most stringent criterion. A stable model has small mean errors with low variability measured in terms of MAPE, RMSPE, PRESS, FPE, AIC and so on. The model should be able to pick up the turning points and should have no drift. In a robust model, *ex ante* dynamic forecasts are not less accurate than those within the sample.

### **Dealing with Instability**

Rarely does a money demand function fulfill all the 3-P criteria for stability. Whatever its causes, methods to deal with instability need to be systematically examined. The underlying concern is whether money demand is genuinely unstable or the indications of instability are due to imperfect knowledge of the complex real world and modeling failures. The possible causes of model failure are (i) omitted or inappropriate explanatory variables, (ii) mis-specification of the dynamic form, (iii) data or measurement errors and (iv) faulty estimation methods. In this study our search for stability is broadly in these directions.

Identifying the key variables : We first discuss the basic issues that affect aggregate money demand in the Indian economy - the definition of money, the appropriate scale and opportunity cost variables. The

success of model specification and estimation depends on which variables are treated as exogenous. Some have argued that money supply is a function of reserve assets which are determined within the system, and hence endogenous. If this were true, monetary targeting has no meaning. As regards causality, output and interest rates could have a bidirectional relationship with money stock. Neither is the relationship between money and prices free from controversy. At one extreme is the structuralist hypothesis that prices are unaffected by money and the rigid monetarist view at the other.

The consequent modeling issues are related to identification and simultaneity. The thorny questions of causality and exogeneity can crop up in almost any single equation model. A simultaneous system which could take care of some of these problems<sup>12</sup> is beyond the scope of this study. So we concentrate on the main object - namely, the relationship between money and inflation. Therefore we also analyse the inverted money demand relationship, to estimate price as a function of output and money stock. Later, for the disequilibrium analysis, we follow the same approach to estimate cointegrating equations both for real money demand and for prices.

Improving the function : This can be approached in two ways. The first is by examining influences other than the scale and opportunity cost. We consider changes and deregulation in the financial sector, the role of inflation, output shocks, expectations and uncertainty on people's decisions to hold money. The second approach is to examine different modeling techniques and methods to remove econometric problems.

In early empirical research it was customary to model the process of adjustment of the actual to the desired money balances by including the lagged dependent variable in the function.

$$(M/P)_t = f [ Y_t, R_t, (M/P)_{t-1} ]$$

This Goldfeld-type of relationship which we shall call the Partial Adjustment (PA) Model has been extensively used both in India and abroad. In India, the Report of the Chakravarty Committee on Monetary Reforms(1985), is an important benchmark. The analytical framework of this report also relied on money demand functions of this genre. In the earlier part of our study we estimate several partial adjustment models of money demand with reasonably good results.

But the simple PA model is not free from problems. The question of spurious regressions discussed earlier and the suitability of the Koyck-lag specification are related empirical questions. The statistical significance of the lagged dependent variable and the implied slow speed of adjustment, according to Goodfriend (1985) is attributed to measurement errors in the independent variables.

In the mid-seventies, the breakdown of the traditional money demand functions in the US, Canada, UK and elsewhere had showed up as ‘missing money’ - that is, large prediction errors, unstable parameters and unrealistic estimates. Enormous efforts were directed towards identifying the causes of instability and devising methods to overcome them. To eliminate problems of bias, autocorrelation, heteroscedasticity and low efficiency, most money demand analyses during the following decade employed Cochrane-Orcutt procedures, Two Stage Least Squares, instrument variables, Maximum Likelihood methods and so on.

These attempts, which were not always successful, have been reviewed and debated extensively in the literature<sup>13</sup>. Our empirical work with some of these techniques, reported in Sections 2 and 3, provides some insight into money demand behaviour in India over a long horizon.

Modeling the transmission mechanism : In money demand analysis

nowadays, the emphasis has shifted more towards short run dynamics. Major differences surface as soon as we make a distinction between long run behaviour and short run changes in demand. This trail leads us to alternate methods of modelling lags in the money demand relationship. As discussed above, in addition to the PA framework and other conventional techniques, disequilibrium theory suggests another alternative.

In recent years disequilibrium analysis is *de rigueur* to model money demand behaviour. From the voluminous literature abroad, we quote a few illustrative studies of this genre : Hafer and Jansen(1991) find evidence of stability in money demand in the US over the period 1953 to 1988 using the M2 measure. Boughton (1991) has used several EC techniques to analyse money demand in 5 large industrial countries. This study finds, *inter alia*, that long run money demand is stable, but the dynamics are complex. Miller(1991) examines monetary dynamics with a different twist to the ECM - a strategy which claims to overcome the problem of exogeneity and also encompasses the other EC methods. Mark Taylor (1994) applies various test procedures including Monte Carlo methods, cointegration and VAR techniques to demonstrate that for the US, even if the Goodfriend hypothesis of measurement errors is true, efficient estimation of the money demand function is possible. For an open economy model of the UK incorporating the real exchange rate, see Bahmanee-Oskooee (1991). Mcknown and Wallace(1994) test a monetary exchange rate model for 3 high inflation economies - Argentina, Chile and Israel - and find some support for the PPP hypothesis. Of special interest is Montiel (1991) who analyses monetary policy changes in a typical developing country characterised by weak financial markets, capital controls and administered interest rates.

A common thread in all the estimation methods is the focus on error analysis<sup>14</sup>. Despite the enormous research, convincing answers to all the questions have not yet been found. Conflicting theories,

competing techniques, and above all, the failure of the empirical models to make accurate predictions leaves the field wide open.

Disequilibrium models of money demand in India have already made their appearance. In Section 3 we examine the transmission process in money demand behaviour in India, covering both the conventional and newer methods. Of the two types of disequilibrium models estimated in this study the first adopts the BS approach. The framework of the BS models is similar to that of Boughton and Tavlas (1991) who follow the instrument variable route and find empirical support for the BS and EC models in a multi-country evaluation of money demand behaviour. Since the response variables are sticky in India, this seems to be plausible: economic agents hold larger balances till their assets are reallocated, the economy adjusts to the monetary shock and the aggregate demand for money moves towards equilibrium. For the EC models we follow the Engle and Granger two-step procedure: (i) to estimate the cointegrating regression between I(1) variables in levels - that is, the static model and (ii) to estimate a dynamic money demand relationship among I(0) variables difference and lagged as required, together with the embedded EC term. Section 4 discusses the comparative merits of the PA, BS and EC techniques and what they reveal about the demand for real balances in the Indian economy.

## Section 2

### Determinants of Money Demand in India

We now seek to give empirical content to the issues discussed earlier, covering the period 1960-61 to 1992-93. For want of an official quarterly series of national income the estimation is based on annual observations.

#### The Monetary Aggregate

The choice of the dependent variable is based on one's definition of what constitutes 'money'. At one extreme we have Frank Hahn's view that if at all, cash is the only true money - that too, solely because of market imperfections which impose costs on the conversion of assets into liquid cash. Whereas in the broadest definition currency, checkable deposits and all near-monies that are readily convertible into cash would qualify. Our preference for the monetary aggregate is dictated by the objective of the analysis. Narrow money (M1) comprising mostly of non-interest-bearing liquid elements associated with daily economic transactions is sometimes preferred for short run targeting. For overall monetary management, the macroeconomic relationship between money, output and prices is the main concern and therefore, the broad definition of money (M3) is relevant. As more and more money substitutes appear in the financial markets, an even broader measure than M3 may have to be considered<sup>15</sup>

As a prelude to the main analysis it is important to ascertain the unitary price elasticity of the nominal money stock. The following unconstrained equation shows that the price coefficient is not significantly different from unity.

$$m3 = -15.26 + 1.86 YR + 1.01 WP - 0.15 D \quad (1)$$

Here M, Y, WP and D represent nominal money stock, output, price level and interest rate respectively. All subsequent analysis, therefore, pertains to the demand for real balances - that is, M/P where P stands for the wholesale price index.<sup>16</sup>

## The Money Demand Function

The demand for real balances is specified as a function of real economic activity and opportunity cost in the partial adjustment specification

$$mr = b_0 + b_1 yr + b_2 d + b_3 X + b_4 mr_{(-1)}$$

where  $X$  denotes a vector of exogenous variables such as expectations, financial innovation and other such factors. This equation serves as the prototype model for the study. Other specifications are obtained by imposing restrictions on the  $b$ -coefficients or extending the lag structure. Later, for the EC models, the dynamic relationship is estimated in logarithms of first differences.

The list of variables is given in Table 1. In the notation, lower case letters denote logarithms of the original variables and numbers in brackets indicate lags. The suffix 'r' indicates real variables. Unless stated otherwise,  $mr$  refers to real M3 balances,  $yr$  to real economic activity and  $d$  to the opportunity cost, all in natural logarithms. The sample statistics of the models estimated in this study are given in the Tables 3 through 6.

## The Scale Variable

Our first concern is to choose an appropriate scale variable, the one that has an unquestionably strong influence on money demand in India. After extensive experiments with different definitions of real output we find that any standard measure of current income serves well enough. The simplest long run equation with real GDP

$$m3r = -9.25 + 1.72 \text{ yr} \quad (2)$$

explains 99% of the demand for real balances. There are several variations of this equation in the literature. Sometimes the transactions motive is distinguished from the speculative motive by including the consumption and investment components of GDP as separate

explanatory variables. Yet another dichotomy is between the demand for money in the agricultural and non-agricultural sectors. The value of cheques cleared and the volume of retail sales have also been employed in some studies to represent the scale of current transactions.

Is wealth a meaningful variable in the money demand function? This question can be addressed in different ways, depending on one's theoretical inclination. To a Keynesian, wealth (YW) has an influence on money demand, distinct from the transactional element YC.

$$mr = b_0 + b_1 yw + b_2 yc$$

Since current income and the volume of cheque clearances are highly correlated, the latter turns out to be a statistically significant proxy for YC. This is a useful specification for advance forecasts when data on current output is not available. But it is incomplete without a significant variable for the rate of return, which is difficult to obtain in a regime of administered interest rates. Moreover there are practical problems of measuring wealth. Equation (12) in Section 3 suggests another method of studying the effect of output shocks on money demand.

If the permanent income hypothesis is true, the planned expenditures of economic agents are related to their 'normal' or permanent levels of income. To test this hypothesis, a permanent income series was constructed.

$$YP_t = \sum_i W_i YR_{t-i} \quad 0 < = w < = 1$$

YP is a moving average of three lagged values of real GDP where  $W_i$  are assigned equal weights. The length of the lag structure is chosen to smoothen the three-year output cycle in Indian agriculture. We have a precedent in Friedman and Schwartz (1982), where observations are averaged over business cycles. Incidentally, this method mitigates the data measurement errors caused by the difference between the Indian agricultural year (July - June) and the financial year (April - March).

$$m3r = -10.75 + 1.86 y_p \quad (3)$$

Apparently, the permanent income hypothesis is valid for the Indian economy. We earmark this as the "naive model" for comparative evaluation later.

In most of the equations the income elasticity with respect to real M3 lies in the range of 1.7, to 1.9. It passes tests of parameter constancy and is insensitive to the choice of the scale variable. The elasticity shows a slight decline in the last decade, suggestive of a rising velocity<sup>17</sup> commonly observed in developing economies. The corresponding elasticity with respect to M1 is close to unity, suggesting that where transaction balances are concerned, a slight wealth effect<sup>18</sup> probably exists.

### Opportunity Cost

In highly developed economies several interest rates exert a significant influence on money demand. For instance, idle balances decrease when bond rates are high and vice versa. When a broad definition of money is used in the function with a single opportunity cost variable, a downward bias in the estimated interest elasticity is to be expected, because a part of the substitution effects caused by changes in the various rates of return are hidden within the composite monetary aggregate.

The peculiar features of the Indian financial structure - administered interest rates, limited range of financial asset choices, high transaction costs, fragmented markets and informal credit systems - possibly cause distortions in observed behavioural patterns. Thus, interest rates do not change quickly to clear the markets to achieve equilibrium. Differential interest rates have mainly a "shifter" effect, transferring savings from one form of financial asset to another. In India the interest rate structure has been both rigid and static. The different rates have been moving closely as seen from the intercorrelation matrix where almost all elements are above 0.9. Their coefficients of variation during several decades have also been very low. In this context, a single opportunity cost variable representing the return on alternate financial instruments is sufficient for the present.

The interest rates on bank deposits were found to have a negative influence on the aggregate demand for narrow money. In the specification for broad money, under the assumption of constant interest differentials, they are interpreted as the long run return on financial assets, with a negative impact on money demand.

$$m3r = -14.62 + 1.65 yp - 0.37 d5 + 0.31 m3r(-1) \quad (4)$$

Permanent income and the five year deposit rate, for example, capture broad money demand behaviour in a partial adjustment framework. If the industrial climate is perceived as upbeat, people will hold less money and augment their investment in the stock market. We used the Index of Security Prices (SP), the yield on securities (YSP) and the UTI dividend rate as proxies for the expected return on financial assets outside the banking system. Ultimately our choice of the opportunity cost variable for M3 fell on D1, the short term bank deposit rate.

$$m3r = -4.11 + 0.66 yr - 0.12 d1 + 0.69 m3r(-1) \quad (5)$$

The tracking ability of this PA model is later compared with others. In the demand function for narrow money, the price of gold (GP) performs better than the term deposit rate of banks as a proxy for the return foregone by holding cash.

Pegged at policy-determined levels, the role of interest rates in clearing the markets in India has been limited. As expected, one rate turns out to be almost as good as the other, but money demand in India is not insensitive to interest rates. Its elasticity is low (-0.14 for M1 and -0.35 for M3) but significant at the 95% level. When the sample period was gradually advanced, to progressively compare the estimated interest elasticity, there was no evidence of an upward drift (the Gurley-Shaw hypothesis). The nominal interest elasticity has not significantly changed during the period 1960-1993.

### **Reducing Instability**

When exogenous shocks occur, the empirical model does not always perform well. As discussed in Section 1, more often than not, this

apparent instability is a symptom of model failure caused by data measurement errors, omitted variables or mis-specification. It is commonly believed that financial developments and technological changes affect money demand. Inflationary expectations and uncertainty are known to cause short run perturbations in the function. We now examine these factors. The mis-specification problem is addressed later.

## **Financial Developments**

In the developed economies, advanced technology, innovations in the financial sector and sophisticated cash management by corporate bodies have reduced the demand for transactional balances. Some studies have interpreted a reduction in cash balances as a result of adopting better cash management. A possible proxy of this influence is the yield and volume of liquid mutual funds. Daniels & Murphy (1994) find that in the US, households' desired level of money holding is determined not only by their level of expenditures and returns on adjacent assets, but also by the transaction costs for their preferred modes and timings of payment - cash, cheques or credit cards. The time trend, the volume of bank transactions and the growth in bank branches are some proxies which we tried to represent this influence in India. But they turn out to be statistically insignificant in the money demand function.

In an open economy, the exchange rate and other global factors also have an impact on the demand for money. Many studies abroad have found that they do have a significant positive influence on money demand in the UK. The significance of these linkages in India may become apparent in future quantitative studies. It is premature to expect direct empirical evidence of these effects during the sample period.

## **Inflationary Expectations**

The proposition here is that the desire to hold money diminishes in an inflationary environment. The market reacts not only to price

changes but also to people's perceptions of future inflation. How inflationary expectations are formed and how this knowledge can be quantified to find the appropriate variable for expected inflation is a difficult question. Since there is no universally acceptable method, we make an assumption that people rely on past experience: the higher the past inflation, the greater will be their inflationary expectations. Modelled in the simplest possible way, prices may be expected to rise at the same rate as in the previous year. That is  $PX_t = INF_{t-1}$

More realistically, we fitted a distributed lag function of previous years' inflation rates to construct a series of expected inflation which reflects the cumulative effect of the past inflationary pattern

$$PX_t = a_1 INF_{t-1} + a_2 INF_{t-2}$$

Incorporating this as an explanatory variable we have the following model.

$$m3r = -4.18 + 0.65 yp - 0.15d1 - 0.01 PX + 0.73 m3r(-1) \quad (6)$$

In the presence of both expected inflation and interest rate the model performance worsens, probably because of multicollinearity between the two. Hence, either the interest rate or price expectations must be dropped. Ignoring for the moment the lagged dependent variable, either of the following equations may be considered.

$$m3r = -11.04 + 1.88 yp - 0.004PX \quad (7)$$

$$m3r = -11.32 + 1.92 yp - 0.08d1 \quad (8)$$

The significant negative coefficient of PX suggests that the higher the expectations of rising inflation, the lesser is the demand for money.

## **Uncertainty**

Volatile financial markets or drastic changes in fiscal policy could exacerbate uncertainty which might drive economic agents to reshuffle their portfolios. Greater caution by investors would reduce the speculative demand for money, with a tendency to shift from financial to tangible assets. Converting liquid assets to gold as a precautionary measure is not uncommon during uncertain times. Therefore we assume a negative influence of uncertainty on money demand. In India a major source of uncertainty in the monetary sector is exogenous money supply expansion and sudden price movements. In the former case, although the fiscal deficit is the primary cause, its effect is not directly measurable. Changes in foreign exchange reserves has been a contributory factor only in recent times. Ultimately the ups and downs in the general price level reflect the destabilising effect of unusual money supply growth and other unexpected events in the real economy. Prices being the most sensitive of indicators, we equate uncertainty with high variability in prices.

We constructed different series of the uncertainty variable PUN (i) the deviation of current prices from the previous years' average :  $WP_t / WP_{t-1}$ , (ii) the variance of prices :  $\delta^2(WP)$  and (iii) the inability to predict inflation from past behaviour :  $INF_t - PX_t$ . All these instrumental variables yield significant negative coefficients. The third definition of uncertainty is used in the following equations

$$m3r = -2.94 + 0.44 \text{yp} - 0.067d1 - 0.0078 \text{PUN} + 0.81 m3r(-1) \quad (9)$$

$$m1r = -2.19 - 0.35 \text{yp} - 0.13 d1 - 0.007 \text{PUN} + 0.84 m1r(-1) \quad (10)$$

These are fairly representative of the best model of money demand that a conventional PA specification can produce. The highly significant ( $t$ -statistic = 6.3) negative impact of uncertainty on the demand for real balances underscores the importance of maintaining price stability in the economy.

## Sectoral Imbalances and Prices

Relative output or relative prices may be considered as a measure of the differential between rural and urban economies. In our estimates these variables showed an insignificant impact on money demand. In a recent IMF study, Parker (1995) uses this concept to examine money demand in agriculture and industry in India. But the evidence is insufficient to draw valid inferences regarding the hypothesis that the demand for agricultural transactions is different from that of the rest of the economy.

A rare application supporting the RESN theory for India is seen in a three-equation model by Ghani(1991). The study finds a positive relationship between anticipated money growth and inflation, but suggests that short run policy targeting could be counter-productive. Balakrishnan (1991 and 1993) refutes its conclusions, using a different procedure. More importantly, a structuralist inference is drawn that money stock and inflation may move in opposite directions in the Indian economy. Nag and Samanta (1990) also believe that structural constraints play a major role in the inflationary process in India. Structuralists regard sectoral imbalances as more inflationary than money supply expansion. Consider the inverted money demand function

$$wp = 5.25 - 0.66 yr - 0.10 d1 + 0.32 m3 + 0.79 wp_{t-1} \quad (11)$$

This specification captures 99% of the behaviour of prices. It shows that money supply and prices are significantly related. Later we find that they are also cointegrated. A 10% increase in money supply, unmatched by output growth (*ceteris paribus*) will lead to a 3 % price rise. This result is similar to the estimate given in Rangarajan (1994).

It is also argued that inter-sectoral terms of trade affect prices and that inflation ‘causes’ monetary expansion. For a more detailed analysis of the relationship between money, output and inflation one needs a multi-equation model which will yield an endogenised inflation rate with feedback to the financial sector. Such macro models of the Indian economy have been developed<sup>19</sup>. Broadly, they indicate that money supply is partly endogenous and that excess liquidity does cause inflation in the long run. Be that as it may, tracing the effects of monetary expansion through the system is of critical importance.

### Section 3

#### Short Run Dynamics

Adjustment towards equilibrium is a complicated process for which a single lagged dependent variable in the short run model may be inadequate. Thus, mis-specification of the short run dynamics cause instability in the model. In the analysis of money demand in India output shocks and unresponsive interest rates merit special attention.

#### Output Shocks

Agricultural output is subject to the vagaries of the monsoon. Hence exogenous output shocks may need special treatment in the short run model. Money demand would be off its equilibrium when in a particular year (eg: drought) output varies substantially from its 'normal' level. Hence predictions with equations (3) or (4) would fail. A possible solution is to explicitly model the impact of output shocks. Suppose we replace current income with its long run trend value (YT) and define transient income (YS) as the deviation of current output from its long run trend.

$$m3r = -11.63 + 1.99 \hat{y}_t(-1) + 1.72 ys - 0.34 R \quad (12)$$

$$\hat{y}_t = 10.95 + 0.04 T$$

Here the coefficient of YS measures the effect of output shocks. This specification is an alternative to the standard stock adjustment, particularly if the interest rate does not have a lagged effect and the objective is to analyse how money demand responds to fluctuations in output.

Our experiments show that annual output fluctuations, particularly those emanating from the agricultural sector, have significant short run influences on money demand. An important implication of these experiments is that output shocks have to be considered while fine-

tuning monetary policy and in particular, optimising short run credit targets.

### **Sticky Interest Rates**

In a single-equation model, specifying different lag structures for each explanatory variable is one of the methods to study the process of adjustment. A null hypothesis to test is that interest rate changes take a longer time to affect money demand than do changes in output. Distributed lag models lend credence to the postulated null. We estimated several distributed lag models of the type

$$mr_t = a_o + \sum_{i=1}^k b_i yr_{t-i} + \sum_{j=1}^n c_j d_{t-j}$$

These functions were acceptable by the standard criteria for model selection. The estimated income elasticity of M3 was 1.9 and the interest elasticity was -0.9. Their respective mean lags were 0.46 and 0.66. The principal advantage of such models is that they shed light on the lagged influence of output and interest rates, measured by the speeds of adjustment and mean lags. Adjustments to output fluctuations occur within 1 year. But interest changes work more slowly - about 1/3 in the same year and complete adjustment in 2.2 years.

During most of the years under review interest rates in India were administered. The bank rate, the Treasury bill rate, deposit rates and banks lending rates - all these have had limited variability and did not fully reflect the underlying economic fundamentals. Portfolio switches which are normally associated with interest rate changes were further hampered by factors like the limited choice of financial instruments, fragmented markets, people's habitual preferences, high risk aversion and transaction costs. Therefore, a weak money demand response to

interest rate changes is to be expected in the pre-liberalisation years. In the emergent environment of market-related rates, asset preferences are expected to become more interest sensitive.

There are two opposing views regarding the effect of interest rates in a developing economy. Neo-structuralists like Lance Taylor and others believe that higher marginal cost of funds will dampen the demand for credit; which will adversely affect output growth. Hence raising interest rates to control monetary expansion is considered inadvisable. On the other hand Mackinnon and others argue that higher interest rates encourage private savings and investment, so that output will get a boost. From this standpoint, money supply growth is not considered inflationary. To understand how interest rates actually work in increasingly complex markets one would ideally require a simultaneous model with disaggregated data on the asset preferences of various economic agents. This is a fertile area for empirical research in India.

### **The PA Model**

We find that a small set of variables in an adaptive expectations framework yields fairly reliable estimates of real money demand in India. The estimated parameters are given in Exhibit 1. They have been successfully tested for statistical significance and stability. Permanent income (YP) has a highly significant positive influence. The interest rate has the expected negative sign. Changes in the financial structure and technical innovations have yet to manifest a significant impact on money demand. Inflationary expectations (PX) and uncertainty (PUN) exert significant negative influences on aggregate money demand.

## EXHIBIT 1

### Parameters of Real Money Demand In India

Variable	Narrow Money		Broad Money	
	ST	LT	ST	LT
<b>Real Economic Activity</b>				
Real GDP (Y)	0.46	1.15	0.66	1.72
Permanent Income (YP)	0.35	1.20	0.65	1.86
Real Output Fluctuations (dyr)@	0.32	-	0.77	-
<b>Opportunity Cost</b>				
Nominal Term Deposit Rate (D1)	-0.19	-0.76	-0.12	-0.35
Gold Prices (GP)	-	-0.08	-	-
Interest Rate Changes (dd)	-0.10	-	-0.05	-
<b>Exogenous Shocks</b>				
Inflationary Expectations (PX)	-0.009	-0.04	-0.008	-0.04
Price Uncertainty (PUN)	-0.007	-0.04	-0.010	-0.04
Money Supply Shocks (MUN) (Buffer Stock Approach)	0.84	-	1.57	-
<b>Speeds of Adjustment (<math>\lambda</math>)</b>				
Under Partial Adjustment		0.31		0.26
Under Error Correction		0.59		0.39

The estimates are for the years 1961-62 to 1992-93.

ST = Short Term Elasticity; LT = Long Term Elasticity.

@ Impact on the growth in real balances; that is, on dm1r and dm3r.

All the elasticities are significant at the 1% level. The short run elasticities are sensitive to the specification of the lag structure and to the modelling techniques. The long run estimates are more robust.

Modelling a different lag response for each explanatory variable in preference to a catch-all partial adjustment shows that (i) short run changes in real money demand due to exogenous shocks persist for two years or more. (ii) The process of adjustment is different with respect to the scale and opportunity cost factors: The estimated mean lags indicate that money demand responds faster to real output shocks (0.5) than to changes in interest rates (0.7). (iii) Adjustment to the interest rate in nominal terms is faster than to the real rate of return. The implication is that, people adjust more quickly to nominal interest rate changes than to inflation - perhaps a symptom of money illusion.

From the average speed of adjustment we infer that money demand takes about 3 years to fully adjust to exogenous changes. A slightly lower estimate of lambda for narrow money indicates that it adjusts faster than broad money, possibly because the latter has a relatively illiquid term deposits component. A policy implication is that regulatory interest rate changes targeted at broad money are likely to show perceptible results only a year or two after implementation. The demand for narrow money is likely to respond sooner.

So far, our experiments centered on adaptive expectations and conventional methods to ‘improve’ the demand function. We now examine whether the disequilibrium hypothesis is applicable to money demand behaviour in India. The BS model and the EC model are estimated for both M1 and M3.

### **Buffer Stock Models**

The BSA has received hardly any attention in India <sup>20</sup>. In the BS models reported here, we apply the analytical framework for BS models described in Section 1. The following AR process with two lags approximates the systematic pattern of money supply expansion namely, MANT.

$$m_t = a_0 + a_1 m_{t-1} + a_2 m_{t-2}$$

The ‘shock’ variable MUN is that portion of money supply which could not be anticipated. That is,

$$MUN = M - \hat{M}_{ANT}$$

From a visual inspection (confirmed by tests for normality) the MUN series appear to depict random (i.e. unanticipated) changes in money supply growth (Graph 1 and 2). If the buffer stock hypothesis is true, unanticipated money supply shocks should have a positive, significant impact on real money demand. Even in this simple specification with M3UN and M1UN as instrument variables, the models perform well.

$$m3r = -3.88 + 0.63 yr - 0.08 d1 + 1.15 m3un + 0.63 m3r(-1) \quad (13)$$

$$m1r = -2.21 + 0.45 yr - 0.10 gp + 0.48 m1un + 0.72 m1r(-1) \quad (14)$$

Unanticipated money supply increases have a positive, highly significant impact on the demand for real balances. The elasticity is 0.48 for M1 and 1.15 for M3<sup>21</sup>. We infer that the buffer stock approach is a valid framework to model the short run behaviour of real money demand in India. The buffer stock for M3 will accommodate almost about all the unanticipated money supply. For M1, about half the monetary shock will be held as a temporary buffer.

## EC Models

Error correction models take many shapes. The flexibility of this techniques has attracted numerous empirical studies. Exhibit 2 list some recent EC models for the Indian economy. In the exercise reported below, we followed the Engle and Granger two-stage method.

## **EXHIBIT 2**

### **Selected Disequilibrium Models for India**

#### **1) Balino et al (1990)**

Period : 1962-63 to 1988-89 Annual Observations

Technique : An aggregate supply-demand model of inflation. Estimation by Engle and Granger's two-step procedure. DW statistic to test for cointegration.

Findings : The central government's budget deficit and broad money are cointegrated. The price level is stably determined by money supply and import prices, although the role of money in the inflationary process has not been as visible as that of exogenous factors like rainfall.

#### **2) Arrau et al (1991)**

Period : 1971.1 to 1989.3 Quarterly Series

Technique: The demand for real M1, with all variables in per capita terms. Index of industrial production is the proxy for output. DF unit root tests and alternate procedures to model financial innovation, including a random walk for the intercept.

Findings : A study of 10 developing countries. India and Korea - but not the other countries - yield results to support cointegration among the variables in the money demand relationship. Financial innovation was not a significant factor in India.

#### **3) Moosa (1992)**

Period : 1972.1 to 1990.4 Quarterly series

Technique : Index of industrial of production is a proxy for the scale variable. Cointegration-based EC representation for the demand for currency, M1 and M2. Both the Engle and Granger two-step procedure, and Johnson-Juselius multivariate technique were employed. L-M test etc. were used to check for residual serial correlation.

Findings : Currency has unit income elasticity. All 3 monetary measures throw up cointegrating vectors and have non-zero interest elasticity. EC models for currency and narrow money perform better than M2 on statistical criteria.

#### **4) Nag and Upadhyay (1993)**

Period : 1982.4 to 1991.1 Monthly Data

Techniques : Johansen's multi-variate method of cointegration analysis and error correction. The likelihood ratio test statistic facilitates the selection of a normalised eigen vector to depict the long run relationship of nominal money (M1) demand. The index of industrial production is the scale variable.

Findings : Long-term movements in M1 are highly correlated with economic activity and the yield on ordinary shares. The relationship with prices was found to be weak. The performance statistics suggest that the ECM is superior to OLS and Box-Jenkin's models.

#### **5) Parikh (1994)**

Period : 1980.4 to 1992.12 Monthly Data

Technique : Phillips-Perron test for unit roots, VAR model with 6-lags to obtain an ECM for M3.

Findings : A long run cointegrating relationship was established between real money and its determinants - exchange rate, interest rate, inflation and the index of industrial production. The short run EC equation did not satisfy the desired econometric criteria.

#### **6) Joshi and Saggar (1995)**

Period : 1960.61 to 1992.93 Annual Observations

Technique : Phillips-Perron Test for unit roots, Johanson-Juselius procedure to obtain the static equilibrium vectors. Hendry's general to specific modelling strategy to obtain EC models for real M1 and M3. Rigorous residual diagnostics are applied.

**Findings :** Statistically robust money demand functions are obtained, determined by real GDP, financial assets and the real exchange rate. The real exchange rate shows a positive effect and financial assets a negative effect. The implicit income elasticities are on the higher side.

#### **7) Rao et al (1995)**

Period : 1952.53 to 1990.91 Annual Observations

Technique : The price equation is empirically examined using ADF and CRDW tests for unit roots and the Engle-Granger procedure for the ECM. Alternate measures of output and price level are tried to obtain several price equations.

**Findings :** There are stable long and strong short run relationships between prices, broad money and output. The relationship is not as strong in the case of narrow money, the estimates are not dissimilar to the inflation models in our study.

#### **8) Rao and Singh (1995)**

Period : 1970.71 to 1993.94 Annual Observations

Technique : Unit root tests by DF and ADF statistics. Engle and Granger's two-steps method to obtain EC models for inflation and foreign exchange reserves. These form a part of a 20-equation financial programming model estimates by Kalman filters.

**Findings :** Inflation is stably related to a set of composite regressors - change in foreign borrowings, exports to GDP ratio and exchange rate movements. The rest of the excellent empirical results are full-system estimates and not specific to money and inflation.

The null hypothesis is that money holdings (M), real income (Y) and interest rates are cointegrated. We first tested several variables for stationarity (refer Table 2) and identified the set of I(1) and I(0) series. Fitting the OLS regression of M3/P on Y and D, all I(1) series in natural logarithms, the residuals were found to be I(0). Hence we accept the null. The cointegrating regression is

$$m3r = -11.57 + 1.98 \text{ yr} - 0.35 \text{ d1} \quad (15)$$

$$m1r = -7.51 + 1.54 \text{ yr} - 0.08 \text{ gp} \quad (16)$$

One cannot, of course, say with certainty whether the adjustments would be made in money, output or interest rates when an external shock disturbs the long run equilibrium. The issue of causality also arises in making a choice. Nevertheless, the tendency of these three variables to move together in the long run implies that they are stably linked. An important finding is that real money balances in India are co-integrated with real income only in conjunction with an opportunity cost variable : Gold Price (GP) in the case of narrow money and the short term deposit rate (D1) in the case of broad money.

In the second stage an error correction mechanism (that is, an adjustment for departures from the co-integrating regression) is included in the short run model of money demand estimated in first differences. This completes the two-step procedure. The dynamic EC model of the demand for real balances is

$$dm3r = 0.068 + 0.77 \text{ dyr} - 0.05 \text{ dd1} - 0.004 \text{ inf(-1)} - 0.39 \text{ EC(-1)} \quad (17)$$

$$dm1r = 0.053 + 0.32 \text{ dyr} - 0.10 \text{ dgp} - 0.51 \text{ EC(-1)} \quad (18)$$

The complete set of equations comprising the EC models in respect of M3 and M1 are given in Table 5 and 6. All the explanatory variables are significant at the 5% level. The immediate impact of output growth is more on M3 than M1. This has implications for the savings and investment behaviour of economic agents. Inflationary expectations are also a significant factor in the demand for broad money. The impact of fluctuations in gold prices on the demand for M1 is twice as much as the influence of interest rates on growth in broad money demand. As regards the speed of adjustment, corrections for departures from the steady state work faster in the case of M1, than for M3. In the short-run model the significant EC term implies that error correction is an acceptable technique to study short run money demand in India.

The evidence of the EC model is particularly striking in the case of the demand for broad money. We find that price behaviour in India is also amenable to the EC specification.

$$wp = 3.79 - 0.57 yr + 0.42 d1 + 0.60 m3 \quad (19)$$

The cointegrating regression once again confirms that prices, money and output have a stable long run relationship. The EC model of inflation is as follows

$$dwp = -0.02 - 0.52 dyr + 0.005 inf(-1) + 0.57 dm3 - 0.52 EC(-1) \quad (20)$$

For narrow money, it was not possible to find equally compelling evidence of long run stability, particularly in the latter years of the sample period: The money demand equation for M1 barely satisfies the unit root criterion for cointegration, and the residuals in corresponding price equation fail to show the existence of a unit root.

A noteworthy feature is that the nominal interest rate has a significant negative influence on the long run demand for real balances. But in the short run, its impact is low. This is in agreement with the findings of the conventional models reported earlier. These results suggest that insofar as stability is concerned, broad money behaviour is predictably related to output and prices. Year to year price movements are explained by changes in output and money supply, together with an interest rate. The explanatory variables are significant and exhibit the right signs.

The hypothesis of a stable money demand relationship in India is supported by our EC models. Excepting Nag and Upadhyay (1993), the other EC models for money demand cited in Exhibit 2 are in broad agreement with our results, particularly regarding the inflation and money supply nexus<sup>22</sup>.

Are the disequilibrium models superior to the conventional PA models? We make a comparative evaluation in the following section.

## Section 4

### Comparative Evaluation

Having obtained several plausible models of money demand we focus on the issue of stability and model comparisons. Most empirical research on the stability of money demand in India is confined to tests of parameter constancy at a specific time point such as the Chow test. We have attempted to probe this issue in more detail. For analytical convenience all the estimated functions are grouped under three categories - PA models, BS models and EC models.

From our extensive experiments within the conventional equilibrium framework, we chose a ‘naive’ static money demand function (eq. 3) and a few PA models -Eq 5 and 9 for M3 and Eq 10 for M1. In eq. 13 and 14 we have the empirical BS models for M3 and M1 respectively. The EC model comprises of a long run money demand relationship in levels and a dynamic equation to estimate annual growth in real balances. The dynamic relationship for growth in real money demand (M3) is given in eq. 17. Its inverted form (eq. 20) is the EC model for inflation. The static regressions of both these specifications are stable. But the EC model for M1 (eq. 18) is not as robust as the corresponding model for M3.

For uniformity some models were re-estimated employing the same set of variables, for a common sample period. Their tracking performance is presented in terms of annual growth in real balances and their prediction errors (Tables 7 & 8).

We evaluated each model by the 3-P criteria described earlier - namely, precision, parsimony and predictability.

## Precision

Parameter stability is the first criterion. In the estimated models the elasticities and speeds of adjustment are statistically significant. Their signs and dimensions are within theoretically acceptable limits. Having applied the standard F-tests for significant shifts in the structural equation, we employed the more flexible method of forward - lengthening samples. Unlike the simple chow tests, this method does not make *a priori* assumptions about the point of a possible break. The results indicated only one probable break point in 1969-70, the year of banks nationalisation. The period 1978-79 to 1982-83 exhibits slight volatility. Overall, the hypothesis of parameter stability during the years 1960 to 1993 cannot be rejected. This conclusion applies both to M1 and M3.

For M3 in particular, the EC model performance is significant. Not only the money demand relationship, but its inverted form - that is, the price equation was also co-integrated. This confirms that a long run stable relationship exists among the three variables - broad money, prices and real GDP. The stability of M1 is not so well established by the EC model.

## Parsimony

The residuals were checked for autocorrelation. For the PA and BS models we relied on the D-W or h-test, applying the Cochrane-Orcutt procedure where necessary. The EC models passed through the more rigorous tests for unit roots and stationarity. The demand for real money balances (whether M1 or M3) can be explained as a function of a small set of significant variables. The static money demand function with real income and a single opportunity cost variable yields a

significant cointegrating regression of real money demand and explains long run money demand behaviour quite well on the average. For the short run, the best PA model has permanent income, interest rate, price expectations and uncertainty as the major influences, in addition to the usual lagged dependent variable. The BS model shows that unanticipated money supply changes have a significant short run impact on real balances. The EC model underscores the importance of multiple adjustment lags and the existence of stability in the relationship.

### Predictability

How good are the predictions, particularly in the short run? Was there any ‘missing money’ episode in India? We compare the year to year tracking ability, paying special attention to indications of bias and the response to exogenous shocks. The notorious ‘missing money’ episodes in the developed countries had discovered that the model forecasts turned out to be substantially higher than observed real money demand. In the US, for example, out-of-sample dynamic simulations 1974:1 onwards, over-predicted to the order of 9% in M1 and 13% in demand deposits. Even static forecasts displayed the same, though less dramatic, tendency. This evidence of instability which persisted throughout the 80’s, had given impetus to extensive research on the money demand function. This study reports the findings of a similar exercise for India.

### **EXHIBIT 3**

#### **Predictive Power**

##### **Changes in Demand for Real M3**

Measure	Observed growth	PA MODEL	BS MODEL	EC MODEL	PA-PUN MODEL	NAIVE MODEL
%						
Mean Error	6.8	0.1	0.1	-0.1	0	-1.9
Abs.Mean Error	7.8	3.5	3.1	3.7	2.6	6.8
RMSE		4.7	4.2	4.5	3.5	9.1

There has not been a corresponding sudden breakdown of the money demand function in India nor a period of high unpredictability. During the period under study, aggregate real money demand for M3 was estimated with an accuracy of 99%. Estimates of annual growth rates were within 3% of actuals. The models are able to capture the turning points in most of the years (See Graphs 5 & 7). The confidence intervals are also reasonably small. The absolute mean errors (AME) of the three models are 3.5, 3.1 and 3.7. The corresponding RMSE values are 4.7, 4.2 and 4.5 respectively. The PA Model 2, with price uncertainty as a determinant is marginally better than the others. Its AME and RMSE are 2.6 and 3.5 respectively.

#### **EXHIBIT 4**

##### **Predictive Power**

###### **Change in Demand for Real M1**

Measure	Observed growth %	PA Model		B S MODEL		EC MODEL	
		ESTIMATE	ESTIMATE	ESTIMATE	ESTIMATE	ESTIMATE	ESTIMATE
Mean Error	5.5	5.4		5.5		5.4	
Abs Mean Error	7.2		6.1		6.3		6.1
RMSE			4.0		3.5		3.9

We selected a few models for out-of-sample predictions. Each model was first estimated for 10 sub-samples increasing from 10 to 25 years. After estimation, 3-year-ahead forecasts were obtained and their performance was evaluated on the basis of (1) estimation bias, (2) Mean squared errors and (3) Overall performance across all sub-samples.

There was no drift in the successive forecasts. Bias was negligible in most cases. The *ex-ante* predictions 1 to 3 years ahead had low mean errors of 0.6 to 1.3 percent. The latter half of the seventies was comparatively volatile, as indicated by slightly higher than average estimation errors. The estimates did not show signs of "missing money" in India. The overall predictive performance was good and did not show major variation across models.

## **Performance during shocks**

Consider the oil shocks of the seventies. The first shock of 1974 had caused an unprecedented price rise and inflation had jumped from 10% to 20% within a year. This and the subsequent structural adjustments in the domestic economy showed up as a sharp fall in real money in 1974-75. Soon thereafter, severe monetary measures were taken, money supply growth was maintained at 12-13% and inflation came down to less than 5%. In 1979-80 the second oil shock occurred. For four successive years, money supply expanded by around 20% - the highest in 40 years. This pushed up inflation again. Graph 7.1 shows the inflation effect of large money supply shocks in this period. In spite of these severe shocks, the money demand relationship does not show signs of alarming instability. Predictive errors in these volatile years were, of course, somewhat higher than the sample average.

How well do the models predict real money demand growth in unusual years? We compare their performance during 10 occasions of output shocks, money supply shocks and high inflation. The direction of shock and the ranks of the models in predicting money demand growth are given in Exhibit 5. The predictive power of the BS model during exogenous shocks is remarkable. We infer that the buffer stock approach cannot be overlooked while modelling short-run money demand in India. The PA model with price uncertainty as an explanatory variable estimates real money demand ( $M3$ ) growth as good as the EC model.

## **Model Selection**

What do the models estimated in this study reveal about money demand in India? The striking difference between the ‘naive’ model and the PA model is convincing proof - if indeed it were necessary - that when exogenous factors change, people take time to fully adjust their demand for real balances. The uncertainty factor and expectations are extremely important in this process. Our empirical results as well as those of others show that the dynamics of money demand behaviour are far more complex than what a simple Koyck-lag model depicts.

**EXHIBIT 5**  
**Ranking the Models**  
**Tracking Performance During Exogenous Shocks**

Year	Direction of shock	PA Model	BS Model	EC Model
<b><u>Output Shocks</u></b>				
1965-66	-	1	2	3
1972-73	-	3	1	2
1979-80	-	2	1	3
1988-89	+	2	1	3
<b><u>Money supply Shocks</u></b>				
1973-74	+	2	3	1
1974-75	-	3	2	1
1976-77	+	3	1	2
<b><u>Inflationary Expectations</u></b>				
1974-75	+	3	2	1
1975-76	+	1	2	3
1980-81	+	3	2	1
Number of Best Predictions (out of the 10 years)		2	4	4

The 3 models are ranked on the basis of their predictions of change in real money demand (dm3r) during years of unusual exogenous shocks.

The sophistication and elegance of the disequilibrium hypothesis is inviting. But shorn of technicalities, what do the BS and EC models contribute to our knowledge? Unanticipated money supply has a significant positive impact on short run money demand. Almost all of the M3 shock is held as a temporary buffer. The corresponding buffer for M1 is estimated to be about half. These estimates are in line with the range of values ((0.6 to 1.3) obtained by Carr and Darby (1981) for 8 industrial countries.

Given several apparently 'good' alternatives to choose from, the model selection is based on variance dominance or encompassing criteria. This involves various statistical tests on the residuals  $U_t$ <sup>23</sup>. The ability to predict real money demand is the ultimate criterion of a good model. Where the predictive power of the 3 types of models is concerned, we have seen that the choice is not clear cut. Theoretically, the argument in favour of the EC technique is that it ensures better *ex ante* out-of-sample forecasts, hovering round the long run equilibrium path. The significant EC term does indicate that short run shocks are absorbed and a corrective process is initiated for money demand to revert to its long run path. But the annual growth estimates that we obtain are not strikingly better than the PA and BS models. Depending on the variables chosen, the specification, the constraints and estimation methods a variety of EC models could emerge. How good these empirical models turn out to explain money demand behaviour in India time alone can tell. Even in our simple exercises, the evidence of the EC models reinforces the conclusion of money demand stability. Disequilibrium analysis is a potentially useful research methodology. One is inclined to concur with Mark Taylor's view that dynamic modelling incorporating long run constraints is the right road to tread. But more convincing empirical evidence is required before the claim of predictive superiority of the EC model is established.

## **Section 5**

### **Summary and Conclusions**

The demand for real M3 balances in India is strongly influenced by permanent income and interest rates. The former has an average elasticity of 1.8. There are indications of a slight decline in the 90's. The interest elasticity is -0.3. The low value reflects the controlled regime that prevailed during the greater part of the period of our study. The corresponding elasticities for narrow money are 1.1 and -0.8. Both the scale and opportunity cost variables pass the tests of parameter stability.

### **Short Run Dynamics**

As regards short run dynamics, the question of paramount importance is about exogenous shocks and how money demand adjusts to them. The results of our investigations, though tentative, lead to some interesting conclusions. Deviations from the equilibrium path are triggered by inflationary expectations, uncertainty and supply shocks. Money demand reacts differently to each kind of shock. Moreover, these factors are not unrelated. Unanticipated money supply increases are initially absorbed in temporary buffers. Prices are sticky, so the transmission process may take two to three years to fully work through the system.

Ultimately, monetary expansion pushes the general price level upward. This has a deleterious effect not only on inflation, but an indirect impact on peoples' expectations. An output effect of money supply expansion via greater demand, higher credit and investments cannot be ruled out, but the trade-off is too small to offset the price effect. On the other hand, if the economy is deprived of genuine credit requirements, a negative impact on output is possible.

## **Expectations**

Higher stocks of commodities, gold and real estate are still the traditional hedges against inflation. Market rigidities and information gaps increase uncertainty and fuel expectations of higher prices - which could turn out to be self-fulfilling. Expectations in India are far from rational in the Lucasian sense. But they have a significant influence on decisions about holding money or other assets. Because the information accessible to different segments of the market is not uniform, it leads to 'non-rational' responses in the aggregate. Thus one of the strongest arguments against policy intervention collapses. The evidence is in favour of a target of steady monetary growth combined with short run measures for price stabilisation.

## **Modelling Techniques**

Does the choice of technique make a difference? We have evaluated two disequilibrium techniques to study money demand vis-a-vis the conventional adaptive expectations framework. An attractive feature of the EC mechanism is that it provides a reliable test for stability and a flexible tool to model dynamic relationships. Hence the disequilibrium hypothesis merits more detailed empirical investigation. Adjustments in money demand behaviour are much more complex than what the conventional models represents. More importantly, we find that the estimated short run elasticities and other parameters are sensitive to the postulated lag structure and also to the estimation technique. The tracking performance suggests that the empirical BS model has a slight edge over the other two. But at this stage, disequilibrium model does not outperform the conventional PA models. As matters stand, with all the three classes of models we obtain "good" functions that are able to estimate both the levels and annual changes in the demand for real balances.

## **Stability**

Cointegration tests confirm that broad money stock, output and prices have stable long run linkages. Disequilibrium analysis highlights the inherent tendency of money demand to revert to its steady state. In comparison to the notorious missing money experienced in the western countries, money demand in India has been less volatile.

The conventional tests on the partial adjustment equations, as well as the more rigorous EC techniques support the hypothesis that during the period 1960 to 1993, real money demand in India has been stable enough for purposes of prediction and control. The existence of a stable money demand relationship empirically tested in this study re-affirms the relevance of monetary policy in India.

## **Monetary Expansion**

The long run linkage between monetised fiscal deficits, money supply growth and inflation is seen not only in India but in several countries. Changes in money supply in India depend on a number of factors, only some of which are regulated by fiscal and monetary authorities. Moreover, where an unorganised financial market exists, the effectiveness of short run monetary targeting could be diluted. So far, the Indian monetary authorities have sought to regulate money supply and bank credit within the framework of an administered interest rate structure. It is often argued that the prevalent accommodative money supply expansion belies the pretension of targeting. The implication is that the RBI provides whatever credit the government needs, by pumping additional money into the economy. To exercise a degree of control on this expansion the monetary authority changes reserve requirements and prescribes norms for commercial bank credit. A major change is the recent move to phase out over time, automatic monetisation of the government's deficits via *ad hoc* Treasury bills and to place annual limits on *ad hoc* issues in the interregnum. Greater maneuverability <sup>24</sup> in this critical area will

certainly improve the credibility and effectiveness of monetary policy. But it would be absurd to imagine that monetary measures alone will provide solutions to the problems of economic growth, inflation and unemployment. Inflation in India is not solely a monetary phenomenon. Shortfalls in essential commodities, import costs and so on do have strong inflationary effects. In such a situation, monetary policy has an important moderating role, by supporting fiscal measures to hold the price line. However, fine-tuning is less important than stabilisation to correct excessive variations. This will send the right signals to the financial markets where expectations play a major role.

### **Emerging Scenario**

With the restructuring of the economy, will the behaviour of money demand in India in the 90's resemble what happened in the developed economies a decade ago? New money substitutes, technologies and innovations are rapidly making their appearance in the Indian financial system. A gradual decline of the income elasticity is already under way. The increasing velocity possibly reflects better cash management and financial development. But we do not find direct empirical evidence of the impact of these factors on money demand - yet. This study underscores the need for ongoing research to serve as a tool for the formulation of monetary policy.

In future, money demand analysis in India will be concerned with redefining the concept of money, the allocative role of interest rates and expectations. The main objective is to track the impact of alternate policy-induced changes in order to understand the costs and benefits. As interest rates, foreign currency flows and global conditions exert greater influence on the demand for real balances, variables such as the real exchange rate and financial innovations will appear as new elements in the relationship. A fresh look at the monetary approach to balance of payment may be necessary to provide insights into the process of adjustment and stabilisation.

When the UK had moved away from managed exchange rates, its monetary policy had shifted towards targeting short term interest rates. The policy stance in India might also be veering in this direction. As interest rates become more market-determined, monetary policy may be directed towards influencing them via open market operations, while maintaining long run targets for growth in money supply and bank credit. This strategy will show better results when markets gain depth, become more integrated, and the players perceive that transaction costs of portfolio switches are low.

The role of the Reserve Bank of India takes on greater importance as the economy moves along the path of financial sector reforms. With globalisation, there will be greater preoccupation with the need to harmonise fiscal, monetary and exchange rate policies. The growing links in the markets for money, capital and foreign exchange make this a challenging task. As the economic environment changes, the instruments of monetary policy might be wielded differently. But there is little doubt that inflation control will continue to be the dominant concern of monetary management.

## Notes

1. Siklos (1990) critically appraises the historic and econometric evidence on the forces which link monetary and fiscal policies with inflation. For issues related to monetary management in India, see Rangarajan (1991) and Vasudevan (1991).
2. For the US, the Federal Reserve - MIT- Pennsylvania model is famous. Modigliani and Ando also built large neo-Keynesian models. For a survey of monetary models for India such as Pani (1984), Rangarajan and Arif (1990) and others, see Jadhav (1994).
3. See Chitre et al (1995) for a recent asset portfolio-related study in a different context.
4. The works of Sargent and Wallace(1973), Barro (1977), Lucas(1981) and others show the complexities in the analysis of rational expectations and information in economic decision-making. The relationship  $Y = Y_N + \alpha (INF - PX)$  depicts the RESN concept that output deviates from its natural level  $Y_N$  to the extent of the unexpected monetary shock. For a collection of papers on this literature see Fischer(1980).
5. There are many neo-classical models for the industrial countries which find evidence in favour of the RESN hypothesis. For example, Darrat(1986) for Canada and Fackler and Parker(1990) for the US respectively.
6. For a good exposition of the BS notion see Laidler (1990). Different approaches to monetary modelling are found in Goodhart et al (1987). A discussion of the effects of disturbances and the use of dynamics of VAR models with restrictions is found in Blanchard and Quah (1989).
7. Some alternate methods of estimating money supply shocks are:
  - (i) Find an instrument variable using an AR process with two or more lags.
  - (ii) Under RE, M<sub>ANT</sub> is a supply function of the expected values of its determinants - namely, budget deficit, forex assets and the money multiplier.

- (iii) Unlike 1 & 2 above, which are backward-looking, the forward-looking models consider future expected values of output, interest rates and inflation. The assumption is that people plan their desired time-path of money balances on the basis of what they anticipate about the future behaviour of the economy.
8. Transforming time series to achieve stationarity by the method of differencing is associated with Box-Jenkins(1970) and Granger-Newbold(1974).
9. Tests for unit roots have been developed by Dickey and Fuller(1981), Sargan and Bhargava(1985) as also Phillips and Perron(1988). For an overview of the techniques and related analytical issues see Hendry(1986), Johansen (1985), and Granger(1986). Recent developments in cointegration analysis are discussed in Dolado et al (1990).
10. Hendry and Friedman for instance, advocate two polar approaches to modelling adjustments in money demand behaviour, each critical of the other. For an interesting debate by the two protagonists, see the American Economic Review (1991), Vol.81, No.1.
11. Less than 50 observations is ‘small’ by time series standards. When the database itself is limited, it is a moot question whether technical refinements alone can shed more light on the dynamics of the money demand relationship.
12. Tests have been devised by Sims, Sargent, Granger and others to test the causality between related series. Simultaneous systems overcome this problem and some other limitations of the single-equation model. Moreover, they allow one to trace the interactions at work in the economy. See for example, simulation exercises in Arif (1987), Anjaneyulu (1993) and Bhattacharya et al (1994).
13. See Judd and Scadding(1982), Roley(1985), Laidler(1985) and Fair(1987) for reviews of the search for stability in the 70’s and 80’s. See also Stevens *et al* (1987) for an empirical study for Australia, which employs several techniques popular in conventional research. McCallum(1988) discusses many issues in monetary economics. For a collection of money demand studies for developing

economics see Coats and Khatkhate (1985). For a survey of early Indian money demand functions see Vasudevan(1977) and Singh *et al* (1982). The latter, for the first time in India, used quarterly data for the estimation. For subsequent work, see Bhole(1985), Kamiah(1985), Rangarajan(1988), Thornton(1989) and Arif(1990).

14. Because many test statistics and inferences are unreliable when the error term is autocorrelated, it is customary to examine the errors thrown up by the model. If they are serially correlated or heteroscedastic, remedial econometric tools have to be applied. The commonly used methods are the DW or the h-test in a conventional framework. The ARCH effect is checked to avoid being misled by apparent heteroscedasticity. Unit root tests used in an EC model detect non-stationarity in a series and serve the same purpose.

15. Another aspect is the ‘moneyness’ of the components of money stock. Divisia aggregates were used in the early 80’s by Barnett(1980), Spindt(1983) and others. In money demand studies, this concept makes little difference to empirical estimates. In India for example Ghose *et al* (1985) had employed a Divisia index of M3 in a monetarist model. A better approach is to analyse the behaviour of individual components of money - the demand for which is influenced by different factors.

16. The GDP deflator is another possible indicator of the general price level. Since it is highly correlated with the WPI, it makes little difference in estimation.

17. The stock of money (in the long run) rises faster than money income in an economy where there is a secular rise in per capita income. That is, income velocity ( $Y/M$ ) declines secularly as real output rises. During cyclical expansion, however, the velocity rises with real income.

18. Here the wealth effect implies that with a higher level of wealth, the demand for money does not increase proportionately.

19. The macro models of Pani(1984) and Rangarajan and Arif(1990) have examined the trade-offs through counter-factual simulations.

20. We could find only two papers : Paul and Kulkarni (1987) and Bhoi(1995) on BS models for India.

21. The corresponding estimates obtained by Carr and Darby (1981) for 8 industrial countries take values between 0.6 and 1.3. In a recent study Chishti *et al* (1992) applied the VAR technique to analyse the impact of money supply on target variables. Impulse response coefficients were computed to estimate the dynamic effect of exogenous Shocks Variance decomposition was done for further insights. They conclude that fiscally induced Mun has occurred. Monetary expansion strongly affects the price level, but with delayed response that is, sticky prices.
22. Balino (1990) finds that prices in India are linked to money supply and import prices. His estimate of the long run elasticity of the former is 0.39. The international comparison of monetary, fiscal and price indicators is revealing. During the past 3 decades, countries like Indonesia, Italy, Marocco and Portugal which had expanded broad money and credit to Government at a rate less than 20 percent, experienced moderate inflation. In high-inflation economies (Argentina, Ghana, Mexico and Turkey) the corresponding growth rates were around 100 percent. The implication is obvious - monetary expansion and inflation move in the same direction, at similar rates.
23. The predictive power of the model is measured by small values of  $u_t$ . Ideally,  $u_t=0$  and  $\text{var}(u_t)$  is lower than that of all competing models. Technical details of the procedures of error analysis and model selection by encompassing and so on are available in standard textbooks. Davidson and Mckinnon (1993) provide an exhaustive discussion of the latest econometric tools.
24. For a historic perspective to the autonomy of the central bank and its implications, see Rangarajan(1993).

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**Table 1**  
**Data Definitions**

Variable	Definitions
<b><u>Basic Data Set</u></b>	
M1	Narrow Money Stock - Annual Average
M3	Broad Money Stock - Annual Average
YR	GDP at factor cost at 1980-81 prices
WP	Wholesale Price Index (base 1981-82) - Annual Average
GP	Rs. per 10 gms. of Standard Gold at Bombay
CMRT	Inter-Bank Call Money Rate (Bombay)
D1	One year Bank Deposit Rate
D5	Five year Bank Deposit Rate
SP	Index of Ordinary Share Prices (RBI)
UTI	UTI Dividend Rate for Unit-64
T	Time
<b><u>Constructed Series</u></b>	
M1R	Real M1
M3R	Real M3
YP	Permanent Income
R	Interest Rate
INF	Inflation Rate
M1UN	Money Supply Shock : M1
M3UN	Money Supply Shock : M3
PX	Expected Inflation
PUN	Price Uncertainty

**Table 2**  
**Tests for Stationarity**  
**(Unit Root tests)**

Variable	ADF	Type
MI	-2.63	I(1)
M3	-1.12	I(1)
INF	-4.65	I(0)
M1R	-0.26	I(1)
M3R	-0.09	I(1)
YR	-1.73	I(1)
WP	1.22	I(1)
CMRT	-1.42	I(1)
D1	-1.11	I(1)
D3	-2.92	I(1)
D5	-3.57	I(0)
GP	-1.30	I(1)
SP	2.69	I(1)
UTI	-0.18	I(1)

Period : 1960-61 to 1992-93, annual observations. All variables are in natural logs. Each series is tested for unit roots and found to be integrated of order I(1) excepting the INF and D5.

ADF = Augmented Dickey Fuller Test Statistic. Critical Value is -3.4620.

**Table 3**  
**PA Models : Real M3**  
**(Partial Adjustment)**

Sl.No.	Equation	RBSQ	DW	h	SEE
3.1	$m3r = -9.25 + 1.72 \text{ yr}$ (-9.23) (20.09)	0.99	1.85	-	0.067
3.2	$m3r = -10.75 + 1.86 \text{ yp}$ (-21.39) (42.94)	0.98	0.49	-	0.083
3.3	$m3r = -4.11 + 0.66 \text{ yr} - 0.12 d1 + 0.69 m3r(-1)$ (-3.78) (3.80) (-1.50) (7.90)	0.99	-	1.43	0.048
3.4	$m3r = -2.94 + 0.44 \text{ yp} - 0.067 d1 - 0.008 \text{ PUN}$ (-2.24) (2.14) (-0.85) (-6.27) + 0.81 m3r(-1) (8.36)	0.99	-	0.68	0.036
3.5	$m3r = -4.18 + 0.65 \text{ yp} - 0.15 d1 - 0.01 \text{ PX}$ (-2.33) (2.29) (-1.42) (-2.86) + 0.73 m3r(-1) (5.48)	0.99	-	0.36	0.050
3.6	$wp = 5.25 - 0.66 \text{ yr} - 0.10 d1 + 0.32 M3$ (2.25) (-2.43) (1.13) (3.29) + 0.79 wp (-1) (7.74)	0.99		1.75	0.048

Sample : Annual observations 1961-62 to 1992-93

Estimation : OLS with AR(1) corrections when autocorrelation was detected.

Instrument variables and Two stage Least Squaters were employed  
 where needed.

Small case letter represents natural logarithms.

**Table 4**  
**PA Models : Real M3**  
**(Partial Adjustment)**

Sl.No.	Equation	RBSQ	DW	h	SEE
4.1	$m1r = -3.34 + 1.146 \text{ yr}$ (-2.52) (10.19)	0.98	1.74	-	0.059
4.2	$m1r = -3.90 + 1.20 \text{ yp}$ (-6.31) (22.59)	0.96	0.44	-	0.087
4.2a	$m1r = -2.55 + 0.46 \text{ yr} - 0.19 \text{ d1} + 0.75 m1r(-1)$ (-4.05) (4.15) (-2.54) (9.51)	0.99	-	0.52	0.045
4.3	$m1r = -2.19 + 0.35 \text{ yp} - 0.13 \text{ d1} - 0.007 \text{ PUN}$ (-3.68) (3.13) (-2.01) (-6.35) + 0.84 $m1r(-1)$ (11.37)	0.99	-	-1.20	0.032
4.4	$m1r = -2.71 + 0.47 \text{ yp} - 0.20 \text{ d1} - 0.009 \text{ PX}$ (-3.22) (2.99) (-2.13) (-2.62) + 0.77 $m1r(-1)$ (7.42)	0.98	-	-0.40	0.046
4.6*	$m1r = -3.53 + 0.68 \text{ yr} - 0.14 \text{ d1} + 0.58 m1r(-1)$ (-3.90) (4.20) (-1.45) (5.22)	0.99		0.74	0.043
4.5	$wpi = 3.96 - 0.49 \text{ yr} + 0.17 \text{ d1} + 0.28 m1$ (1.87) (-2.07) (1.71) (3.12) + 0.65 $wp(-1)$ (5.06)	0.99	-	2.11	0.049

Sample : Annual observations 1961-62 to 1992-93.

Estimation : OLS with AR(1) corrections when autocorrelation was detected. Instrument variables and Two Stage Least Squares were employed where needed.

\* The Sample period for this equation is 1971-72 to 1992-93.

Small case letter represents natural logarithms.

**Table 5**  
**Disequilibrium Models for M3**

Sl.No.	Equation	DW	h	SEE	Box - Q
<b>BS Model for Money Demand</b>					
5.1	$m3r = -3.88 + 0.63 yr - 0.075 d1 + 1.15 m3un + 0.69 m3r(-1)$	-	1.40	0.044	
5.2	$m3r = -11.57 + 1.98 yr - 0.35 d1$	CRDW = 1.06		0.086	38.40(15)
	(-11.23) (18.23) (-2.65)	ADF = -3.36			
5.2a	$dm3r = 0.068 + 0.77 dyr - 0.05 dd1 - 0.004 inf(-1) - 0.39 EC(-1)$	1.48	-	0.047	31.71(15)
	(4.19) (2.73) (-0.49) (-2.64) (-3.64)				
<b>EC Model for Inflation</b>					
5.3	$wp = 3.79 - 0.57 yr + 0.42 d1 + 0.60 m3$	CRDW = 1.03		0.066	38.40(15)
	(1.35) (-1.31) (4.09) (6.96)	ADF = -3.36			
5.3a	$dw = -0.02 - 0.52 dyr + 0.005 inf(-1) + 0.57 dm3 - 0.52 EC(-1)$	1.98	-	0.040	20.72(15)
	(-0.82) (-2.41) (4.06) (2.96) (-4.29)				

The models are selected on the basis of CRDW and the Augmented Dickey-Fuller (ADF) test for stationarity of the residuals. The critical value for the ADF is -3.4620 for 5% level and -3.1570 for 10% level  
 Sample : Annual Observations 1961-62 to 1992-93.  
 Small case letter represents natural logarithms.

**Table 6**  
**Disequilibrium Models for M1**

Sl.No.	Equation		h	SEE	Box - Q
<b>BS Model</b>					
6.1	$m1r = -2.21 + 0.45 \text{ yr} - 0.10 d1 + 0.48 m1un$ (-3.24) (3.79) (-1.16) (1.23) $+ 0.72 m1r (-1)$ (8.67)		1.14	0.04	
<b>EC Model*</b>					
6.2 *	$m1r = -5.06 + 0.98 \text{ yr} - 0.12 gp + 0.84 m1un$ (-5.97) (7.22) (-4.66) (7.74) $+ 0.72 m1r (-1)$ (5.74)		0.95		
6.3 *	$m1r = -3.42 + 0.72 \text{ yr} - 0.03 d1 + 0.08 m1un$ (-4.2) (4.80) (-0.27) (1.99) $+ 0.50 m1r (-1)$ (4.71)		0.76	0.39	
6.4	$m1r = -7.51 + 1.54 \text{ yr} - 0.075 gp$ (-5.34) (10.78) (-1.75)	CRDW = 1.08 ADF = -3.47		0.004	38.81(11)
6.4a	$dmlr = 0.053 + 0.32 dyr - 0.10 dgdp - 0.51 EC(-1)$ (2.45) (1.09) (-1.28) (-3.08)		-	- 0.032	14.76(11)

The money demand models are selected on the basis of CRDW and the Augmented Dickey-Fuller (ADF) test for stationarity of the residuals. The critical value for the ADF is -3.4620 for 5% level and -3.1570 for 10 % level  
 Sample : Annual Observations 1961-62 to 1992-93.

\* Based on truncated sample 1971-72 to 1992-93.

Small case letters represents natural logarithms.

**Table 7**  
**Comparative Performance : Demand for Real M3**

YEAR	Observed Growth Rate	Estimated Annual Growth in Percentage				
		1 BS MODEL	PA Model	EC MODEL	PA Model 2	NAIVE MODEL
1963-64	2.4	2.3	2.2	5.0	4.3	-6.6
1964-65	-0.5	4.0	2.1	5.0	0.9	3.4
1965-66	2.4	1.0 (1.2)	-2.4 (2.2)	7.9 (-3.4)	3.6 (-0.5)	-2.5 (6.2)
1966-67	-2.3	1.1	-1.6	0.3	-2.7	-3.1
1967-68	-2.2	6.1	2.1	-0.3	3.6	13.4
1968-69	12.0	8.7	7.1	4.4	12.7	21.2
1969-70	9.0	9.4	9.5	9.3	7.0	20.5
1970-71	7.4	8.9 (-1.6)	8.1 (-0.3)	15.3 (-2.0)	9.7 (-1.3)	20.2 (-97)
1971-72	8.4	7.2	7.5	13.5	9.5	13.9
1972-73	5.8	4.4	6.0	9.6	4.8	4.5
1973-74	-0.3	5.7	9.8	5.9	-1.7	6.6
1974-75	-9.3	6.3	2.2	5.2	-2.8	9.1
1975-76	13.7	12.2 (-3.5)	10.6 (-3.6)	1.7 (-4.8)	17.8 (-1.9)	39.4 (-11.1)
1976-77	17.3	8.7	15.8	8.9	5.8	25.3
1977-78	14.2	12.6	14.3	13.7	12.7	20.8
1978-79	20.3	12.0	13.5	13.5	16.8	15.9
1979-80	2.7	0.2	2.2	13.7	-2.9	-12.0
1980-81	-1.2	2.3 (3.5)	0.7 (1.4)	3.1 (3.1)	2.1 (3.8)	-3.6 (1.4)
1981-82	6.9	6.0	7.3	-1.8	4.9	8.0
1982-83	9.0	6.0	3.4	1.4	7.3	6.5
1983-84	9.1	8.7	10.4	4.1	6.8	11.7
1984-85	11.0	8.5	9.3	9.1	10.3	9.2
1985-86	12.2	7.5 (2.3)	6.7 (2.2)	7.4 (2.8)	11.0 (1.6)	5.3 (1.5)
1986-87	11.1	6.7	6.7	6.7	9.0	0.9
1987-88	8.1	5.2	4.5	6.0	7.2	-2.4
1988-89	9.6	9.8	9.7	4.1	9.6	7.3
1989-90	10.7	11.6	11.9	7.2	10.4	9.7
1990-91	5.7	11.6 (0.1)	8.7 (0.8)	9.3 (3.7)	9.6 (-0.1)	7.5 (4.5)
1991-92	3.1	7.3	7.3	9.0	6.6	3.6
1992-93	7.5	9.1	9.7	5.1	10.8	7.5

Naive Model : Static model with real output as the only explanatory variable.

PA Model 1 : Conventional Koyck lag specification.

PA Model 2 : With Price Uncertainty as an additional variable.

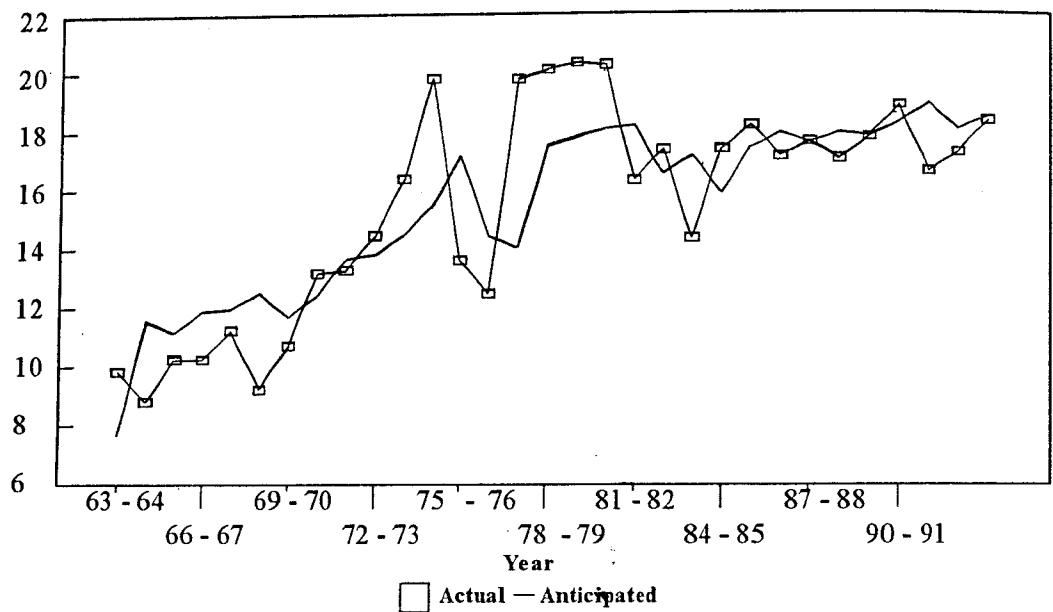
Figures in brackets are 5-years average prediction errors.

**Table 8**  
**Comparative Performance : Demand for Real M1**

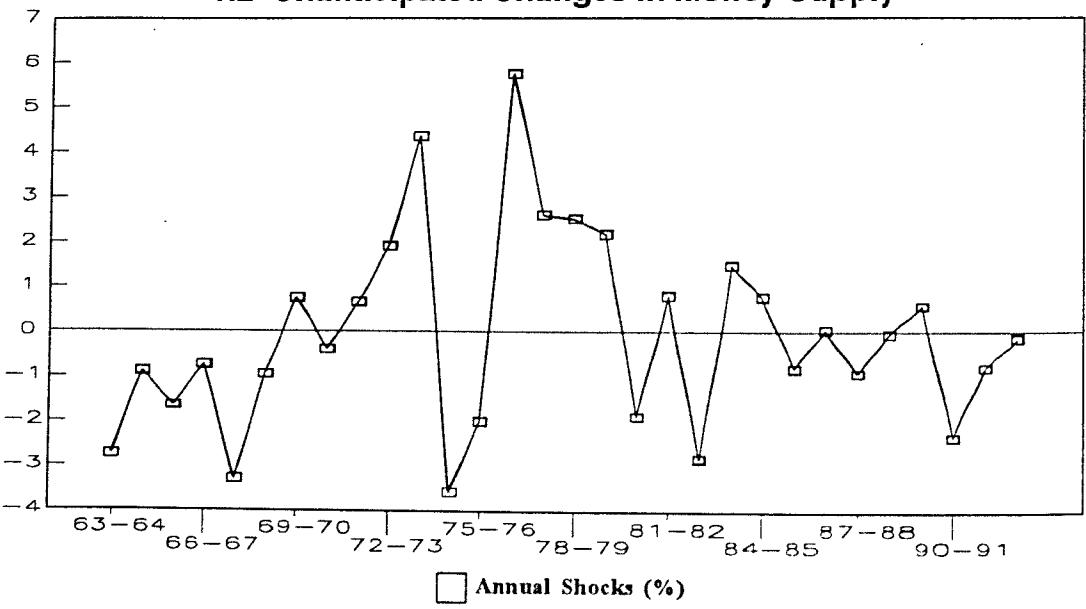
Year	Observed Growth Rate	Estimated Annual Growth in Percentage		
		PA Model*	BS Model	EC Model
1972-73	2.0	-2.7	-4.9	0.7
1973-74	-2.4	-0.5	0.6	-2.1
1974-75	-11.3	1.0	-2.5	0.7
1975-76	7.0	8.4	5.6	12.6
1976-77	10.7	6.3	9.0	13.9
1977-78	8.9	11.6	10.6	9.7
1978-79	17.9	11.7	12.6	9.1
1979-80	1.6	-1.6	-0.4	-1.4
1980-81	-4.1	0.5	-1.1	-2.8
1981-82	4.4	5.6	6.8	5.0
1982-83	5.9	5.9	3.9	7.5
1983-84	6.6	9.1	9.9	7.8
1984-85	11.1	9.0	11.8	9.3
1985-86	9.1	6.8	5.2	6.5
1986-87	8.4	6.0	4.8	5.6
1987-88	5.9	4.3	3.2	0.8
1988-89	6.7	9.1	7.8	5.4
1989-90	11.9	11.2	13.6	9.2
1990-91	6.6	9.7	8.5	7.4
1991-92	4.8	4.0	6.6	4.7
1992-93	4.8	4.8	3.9	6.0

\* PA model with Price Uncertainty

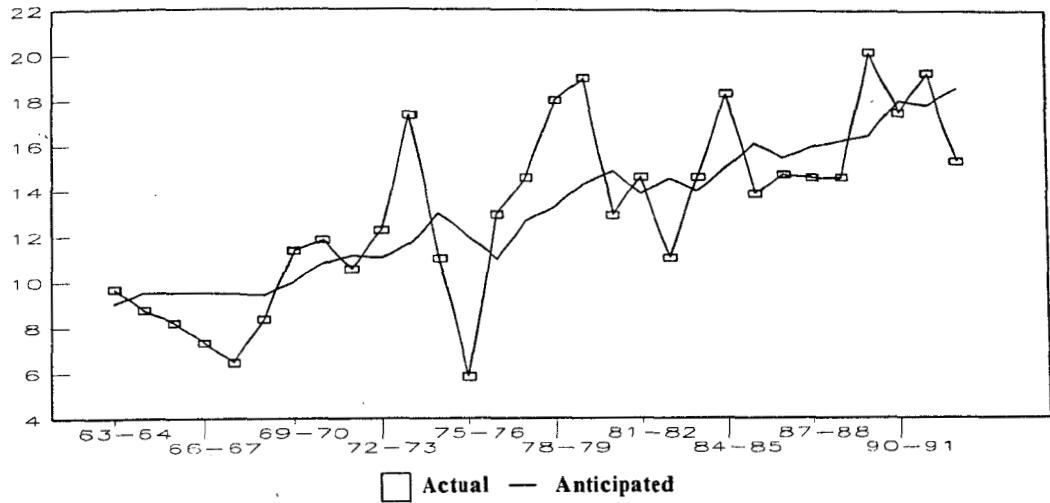
**GRAPH 1**  
**MONETARY EXPANSION AND SHOCKS IN M3**  
**1.1 BROAD MONEY STOCK**



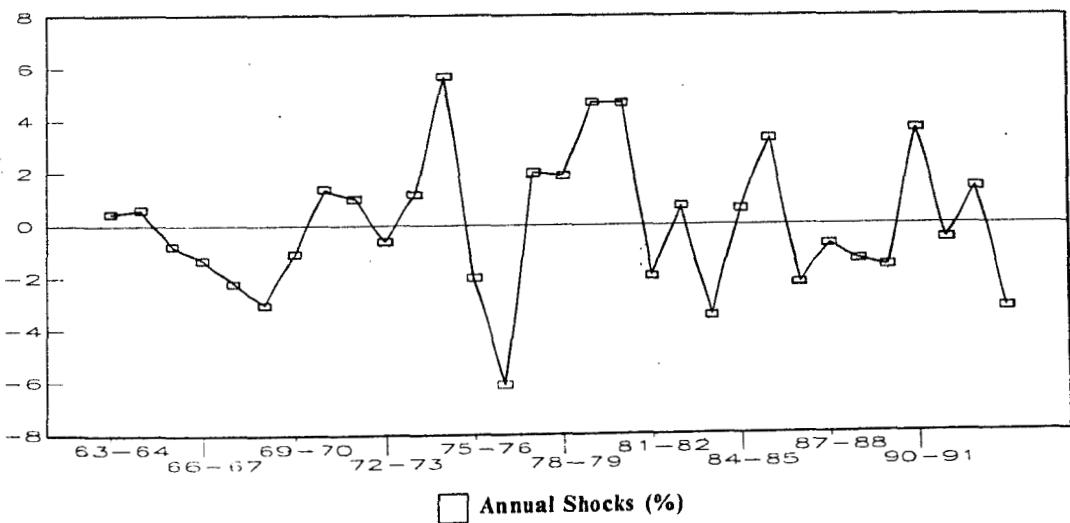
**1.2 Unanticipated Changes In Money Supply**



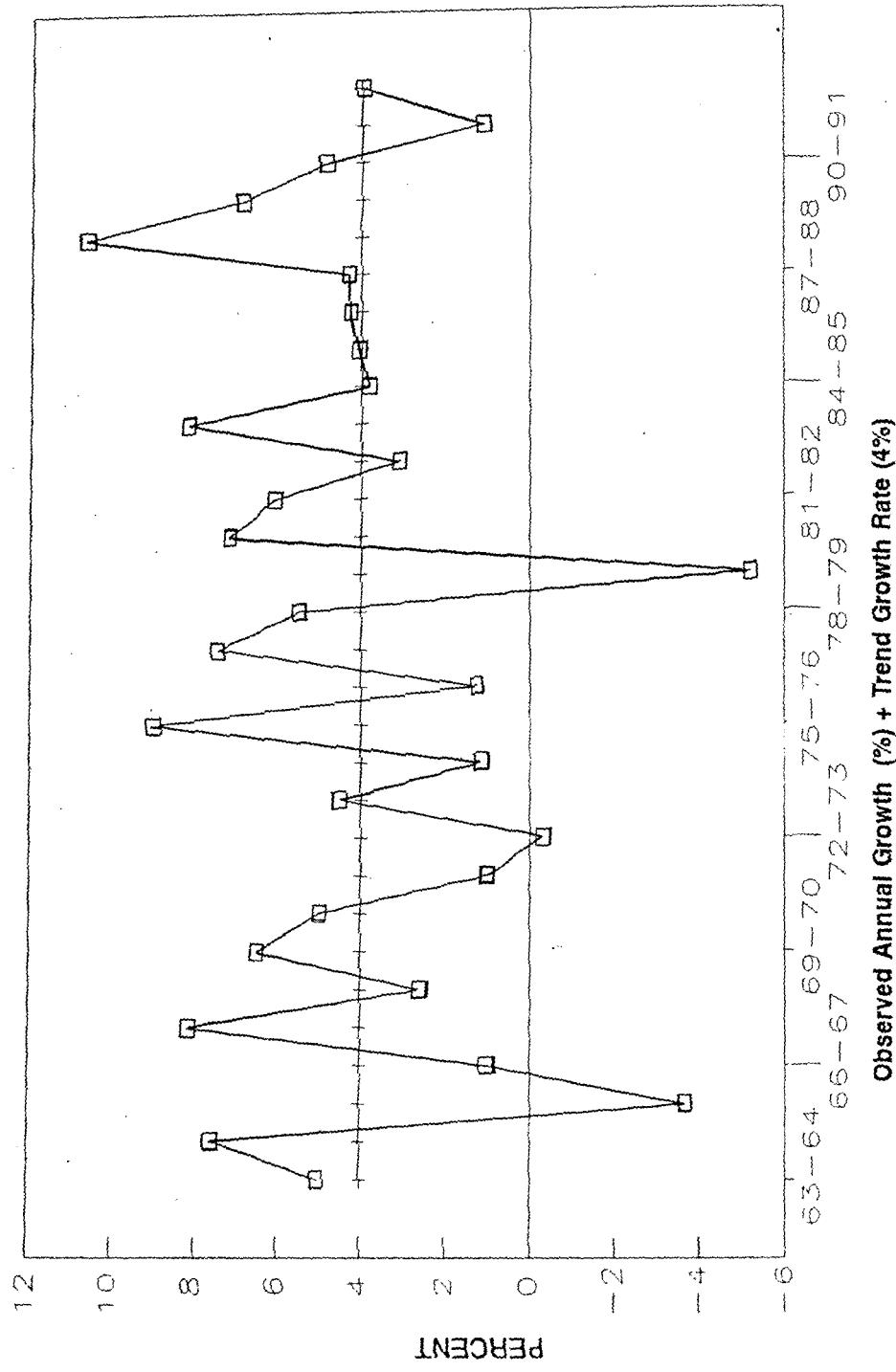
**GRAPH 2**  
**MONETARY EXPANSION AND SHOCKS IN M1**  
**2.1 ANNUAL GROWTH IN NOMINAL MONEY STOCK**



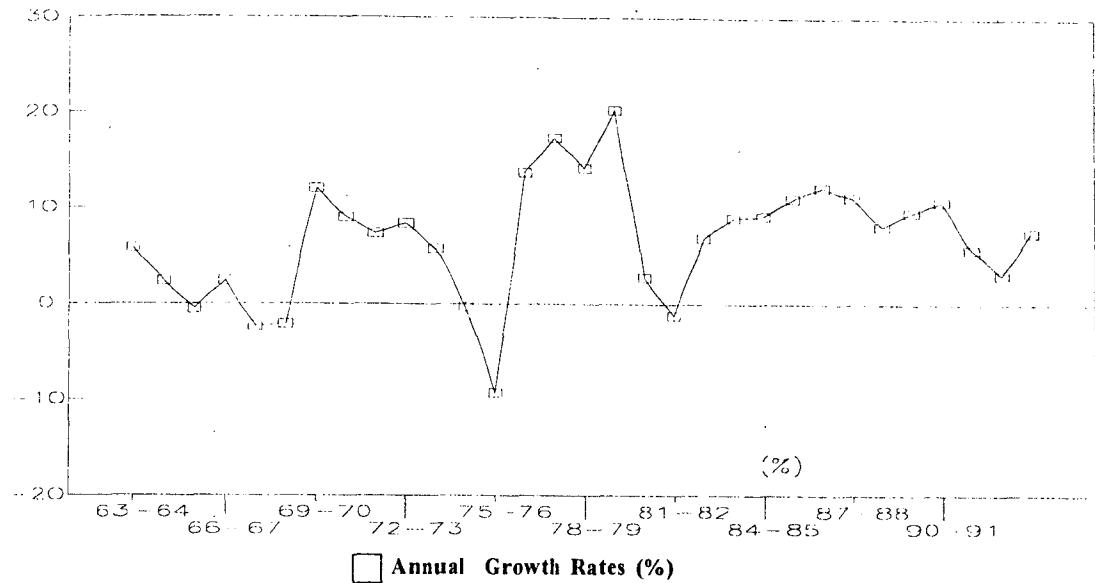
**2.2 UNANTICIPATED CHANGES IN MONEY SUPPLY**



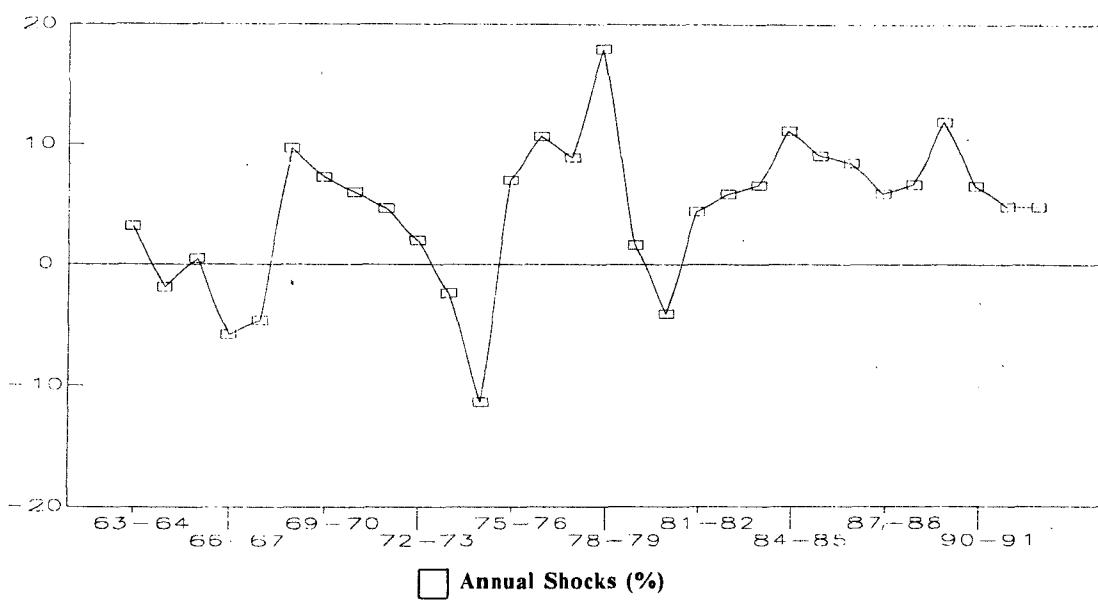
**GRAPH 3**  
**OUTPUT SHOCKS**  
**REAL GDP GROWTH**



**GRAPH 4**  
**REAL MONEY DEMAND**  
**4.1 BROAD MONEY (m3)**

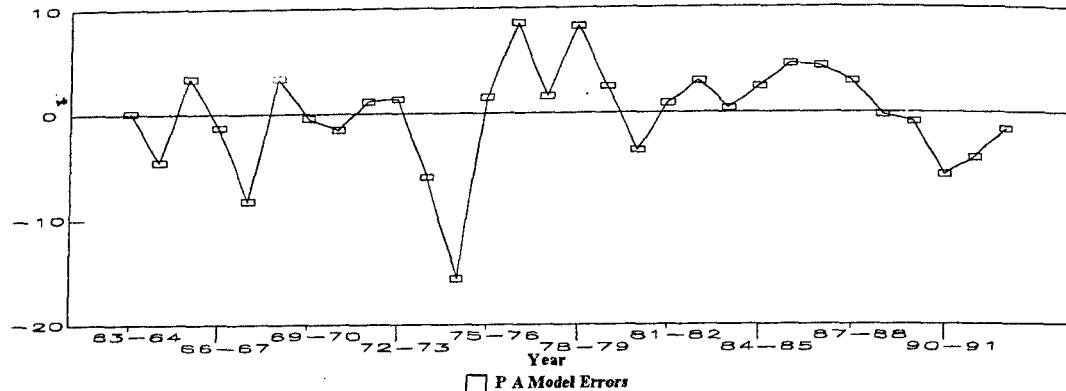


**4.2 NARROW MONEY (M1)**

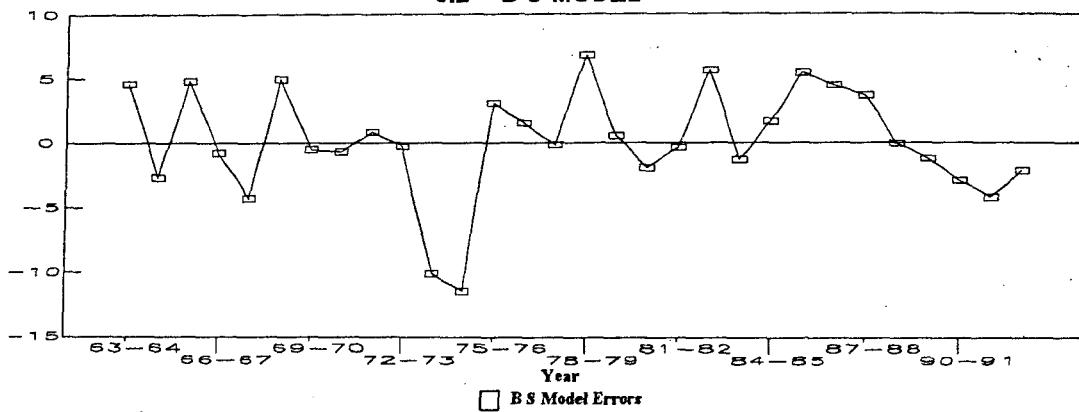


**GRAPH 5**  
**PREDICTION ERRORS IN REAL M3 GROWTH**

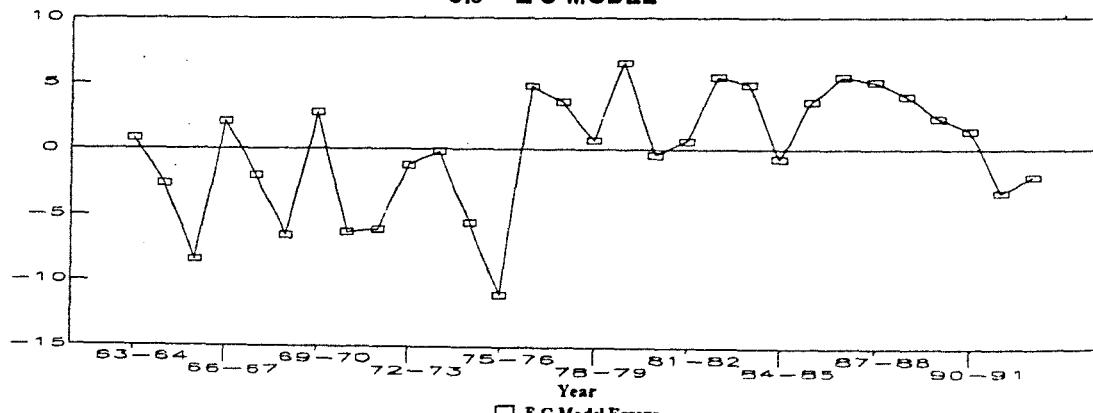
**5.1 P A MODEL**



**5.2 B S MODEL**

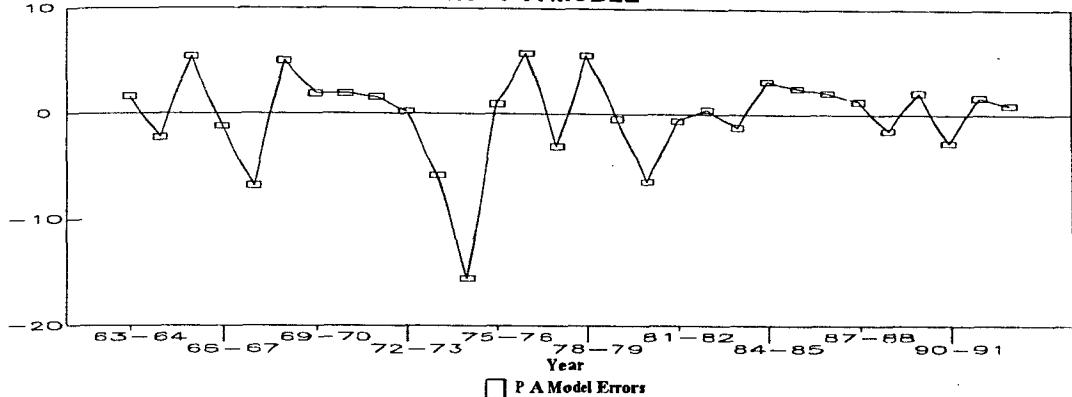


**5.3 E C MODEL**

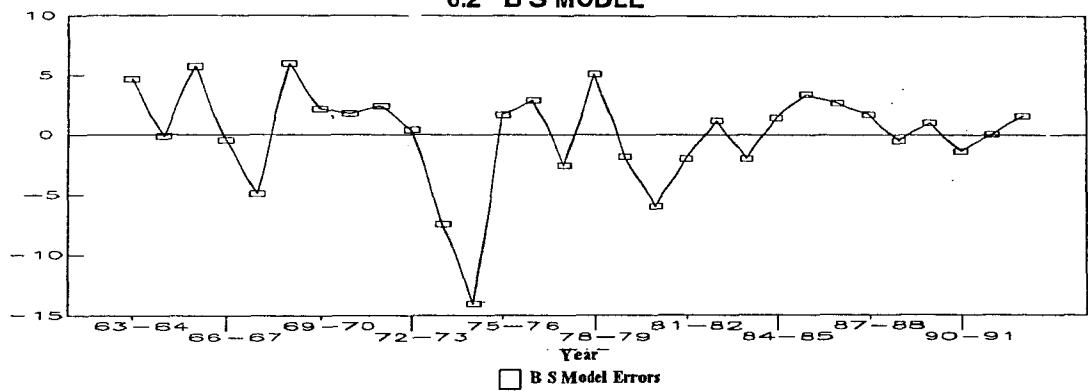


**GRAPH 6**  
**PREDICTION ERRORS IN REAL M1 GROWTH**

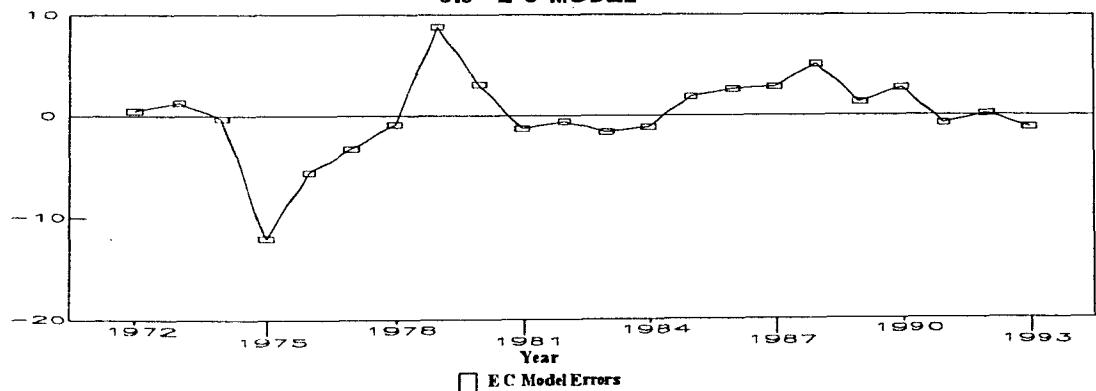
**6.1 P A MODEL**



**6.2 B S MODEL**

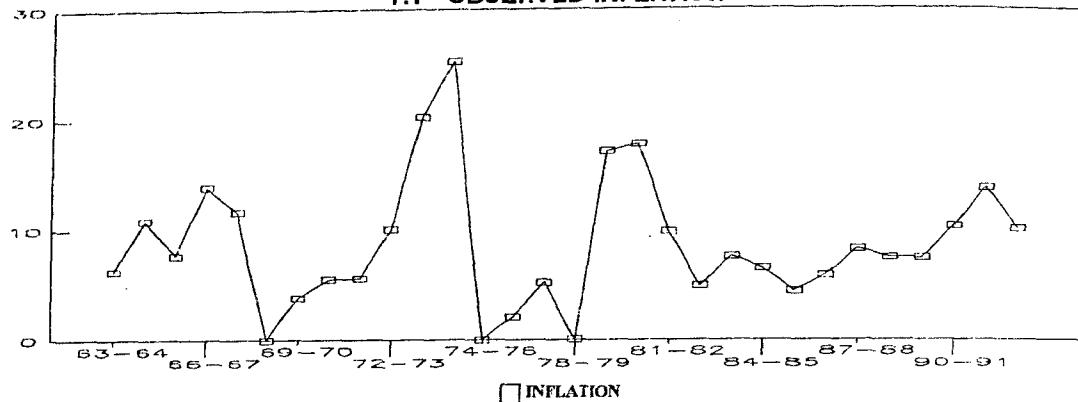


**6.3 E C MODEL**

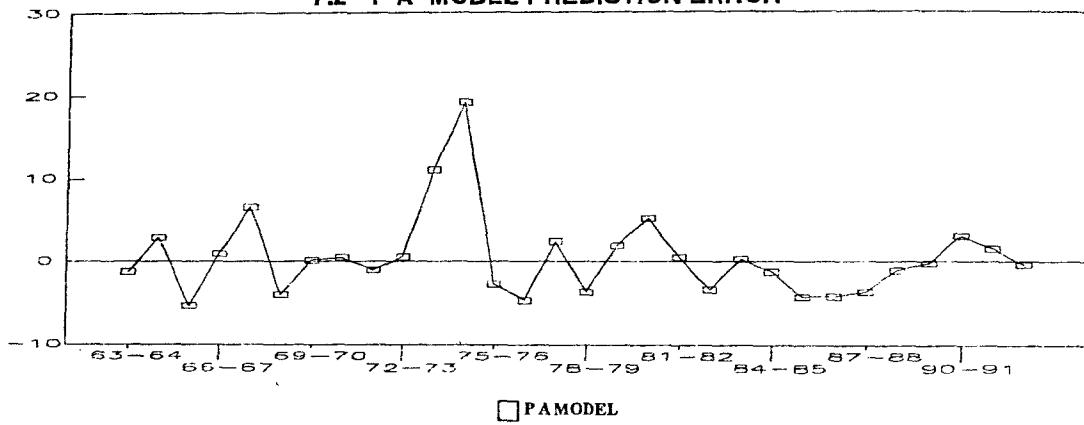


**GRAPH 7**  
**PREDICTION ERRORS IN INFLATION**

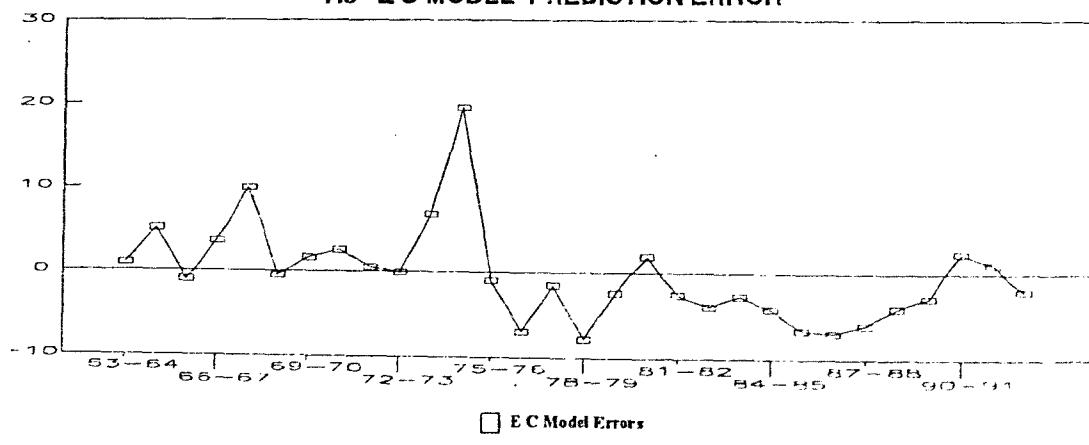
**7.1 OBSERVED INFLATION**



**7.2 PA MODEL PREDICTION ERROR**



**7.3 EC MODEL PREDICTION ERROR**



□ EC Model Errors

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