RESERVE BANK OF INDIA

OCCASIONAL PAPERS

VOL. 17 NO. 4 DECEMBER 1996

The Reserve Bank of India Occasional Papers contains contributions by the Staff of Reserve Bank of India. Articles, notes and reviews published in this journal do not necessarily reflect the views of the Editorial Committee or of the Reserve Bank of India. Responsibility for the views expressed and for the accuracy of statements contained in the contributions rest with the author(s).

Subscription rates for 1996 are :

Inland : (i) Rs.140 (for four issues of the 1996 volume inclusive of postage).

(ii) Rs.35 (for a single issue of the 1996 volume inclusive of postage).

Foreign : (i) US$ 100 (for four issues of the 1996 volume inclusive of registered air mail charges).

(ii) US$ 25 (for a single issue of the 1996 volume inclusive of registered air mail charges).

There is no special rate for any category of subscribers. Subscriptions and orders, accompanied by cheques/drafts drawn on Mumbai in favour of Reserve Bank of India, should be sent to :

The Director,
DRRP (Sales Section),
Department of Economic Analysis and Policy,
Reserve Bank of India,
Amar Building (Ground Floor),
Post Box No. 1036,
Mumbai 400 001 (India).

All other correspondence may be addresed to the Editor, Reserve Bank of India Occasional Papers, Department of Economic Analysis and Policy, Reserve Bank of India, Post Box No.1036, Mumbai 400 001.

RESERVE BANK OF INDIA

OCCASIONAL PAPERS

VOL. 17 NO. 4 DECEMBER 1996

Published by M.S. Mohanty for the Reserve Bank of India and printed by him at Vijay Corporation, 65 Ideal Industrial Estate, Lower Parel, Mumbai-400 013.

Reserve Bank of India Occasional Papers
Vol. 17, No. 4, December 1996

Do Inflationary Shocks Affect Growth in India?

Himanshu Joshi and Partha Ray*

This paper attempts an empirical investigation of the effect of inflation uncertainty on real growth in the Indian economy. The empirical analysis is conducted in keeping with a clear theoretical distinction between the essential features of Friedman's and rational expectations hypothesis by incorporating measures of (i) anticipated and unanticipated inflation rates, and, (ii) inflation uncertainty in the specification of the aggregate Lucas (1973) supply curve. A time varying parameter model is estimated by the Kalman Filter to obtain rational and efficient one-step ahead measures of anticipated inflation; unanticipated inflation and its uncertainty are extracted as derivatives. Results indicate that anticipated rate of inflation does not affect average output growth adversely. However, growth may suffer drastically during specific episodes of very high inflationary pressures arising out of exogenous factors such as oil shocks. Unanticipated inflationary shocks create a consistent and significant loss in real output indicating the presence of a direct trade-off between inflationary shocks and growth, and thus, lends a strong support to Lucasian hypothesis. Friedmanian hypothesis about the adverse impact of inflation uncertainty on growth too is found to be tenable when the measurement equation is couched in terms of M_3.

Introduction

The notion that inflation and inflation uncertainty are detrimental to economic growth has gained currency in recent years. The belief was, in fact, quite contrary during the forties. Thinking in terms of the celebrated Phillips Curve, economists believed that there was a positive trade-off between output and inflation. This was perhaps first challenged by Milton Friedman . Friedman (1968) in his Presidential Address to American Economic Association observed, "Our economic system will work best when producers and consumers, employers

* Himanshu Joshi and Partha Ray are Assistant Advisers in the Department of Economic Analysis and Policy of the Reserve Bank of India. The authors are indebted to Dr. A. Vasudevan and an anonymous referee of this journal for their extremely insightful comments on an earlier version of the paper. However, the responsibility of any error lies solely with the authors. The views expressed in this paper are authors' personal views.

and employees, can proceed with full confidence when the average level of prices will behave in a known way in the future – preferably that it will be highly stable" (p. 13). Friedman (1977) further elaborated on this theme and pointed out that an increased variability of actual or anticipated inflation may raise the natural rate of unemployment (and thus may affect output growth adversely) in two ways. First, increased volatility shortens the optimum length of unindexed commitments and makes indexation to be advantageous. Since such new contractual arrangements take time, therefore, increased variability of inflation is likely to hamper efficiency, at least temporarily. Secondly, increased variability of inflation renders market prices to be a less efficient system for coordinating economic activity. Thus, the long run Phillips curve in the unemployment-inflation plane may turn out to be even positively sloped, and hence stable prices are likely to foster economic growth in the long run.

The idea took a different turn following the rational expectations revolution. Lucas and many of his associates made a clear-cut distinction between *anticipated and unanticipated* inflation.[1] After all, so long as inflation is perfectly anticipated, all the relevant contracts can be written with perfect indexation clause, so that nobody suffers. Perhaps the only minor trouble that anticipated inflation can lead is that in the form of menu costs, like the costs associated with printing of new price tags. Nevertheless, Lucasians argued that optimizing rational agents may make mistakes in extracting information from price signals and accordingly may get confused between an absolute price change and a relative price change. Lucasians hypothesized that output growth is invariant to anticipated inflation but is affected by unanticipated inflation in the short-run.

These considerations are, however, short-run in nature. These theoretical models are concerned with output-inflation trade-off, and not *per se* with growth-inflation trade-off. In the present context our main concern is the long-run relationship between growth and inflation. The earlier neo-classical growth model with money (e.g., Tobin, 1955, 1965) assumed real balance as a substitute to real capital where inflation would affect the level of output but not the steady-state growth rate. In fact when inflation is high there will merely be a portfolio substitution of the wealth-holders in favour of physical capital and away from money. The new endogenous growth theories on the other hand hinted at a negative association between inflation and growth. In this context, Choi, Smith and Boyd (1996) try to explain the negative relationship between inflation and growth in an information-theoretic framework. They argue that in the presence of information-asymmetry, inflation tends to accentuate a number of financial market frictions, and thus, interferes with the provision of investment capital as well as its allocation.

Though theoretical models in this regard are still in the developing stage, recent research in this field points towards an adverse impact of inflation on growth.[2] Three channels have been emphasised, in particular. First, higher anticipated inflation may affect saving and investment and consequently, the intertemporal allocation of resources. Secondly, unanticipated inflation generates inflation uncertainty, and thereby discourages longer-term contract. This may also raise risk premia on interest rates, affecting investment adversely. Finally, since higher inflation is associated with higher relative price variability, price signals get more noisy, and thus, affect the efficiency of the price mechanism to allocate resources among various sectors.

In this context the nature of Indian inflation needs some mention. Quite often the interpretation on the nature and causes of inflation in India is guided by different theoretical paradigms. The structuralist school generally emphasise on wage cost, raw material cost, and capacity utilisation, while the monetarist school stresses on the quantum and cost of money. Empirical findings generally support the eclectic approach in explaining the various episodes of inflationary spurts in the Indian economy. We stress both demand and supply side factors, like changes in money supply, oil price, and aggregate demand in our analysis to explain and make an empirical assessment of three crucial variables *viz.*, inflation variability, anticipated, and unanticipated inflation on the growth rate of the Indian economy.[3]

The scheme of the paper is as follows. Section 2 discusses some stylized facts about inflation uncertainty and output growth for India, and takes a look into a number of specific episodes of inflationary shocks. Section 3 is in the nature of a methodological prologue. The results for India and their implications are taken up in section 4. Section 5 concludes the paper.

Section II

Some Stylized Facts of Growth and Inflation Uncertainty in India

The period of our study is 1970-71 to 1994-95, i.e., 25 years. Though this choice of time period leaves us with less number of observations, still we have preferred not to go back earlier to seventies. After all, the pre-seventies was generally not marked by inflationary spurts, and many of the inherent structural parameters underlying economic policy making were quite different in the pre-seventies period.[4]

During the period under view, while average growth rates for narrow money (M_1) and broad money (M_3) were 15.02 per cent and 17.38 per cent, respectively, GDP at 1980-81 prices (Y) and Wholesale Price Index (P, with 1980-81 = 100) grew at rates of 4.40 per cent and 9.06 per cent, respectively. The average rate of inflation on the basis of price index for manufactured products turned out to be slightly lower at 8.78 per cent. However, there appears to be a good deal of variation in individual years on either side of the mean in each of these variables. Of the money stocks, M_1 appears to be more variable than M_3 with the coefficient of variation of the former at 24.45 per cent being more than double of the latter at 12.09 per cent. On the other hand, the coefficient of variation of real growth rate at 76.05 per cent is found to be little higher than that of 66.81 per cent for the rate of inflation; coefficient of variation for inflation rate in terms price of manufactured products turned out to be 64.77 per cent.[5] It is, therefore, evident that the Indian economy witnessed rather large fluctuations in the rate of inflation. Large variations in the rate of inflation could imply a perceptible increase in the degree of uncertainty among economic agents as argued by Friedman (1977). The *ex-post* variations in the rate of inflation can be partly explained on the basis of the realised values of both money and real growth. Nevertheless, an increase in uncertainty about inflation can restrict growth to a much more extent. Consequently, the expected rate of inflation based only on money and real growth may turn out to be erroneous due to changes in the inflation rate. The existence of a rational forward looking behaviour of risk sensitive agents implies that even if the monetary authority follows a restrictive policy for controlling inflation in the short term, an environment of inflation uncertainty can diminish its effectiveness. A monetary policy seeking to control inflation, therefore, needs to be credible in order to instil confidence among economic agents. For instance, many central banks always keenly emphasise a stance of austerity and low inflation which results in an enhancement of the effectiveness of their inflation management policy. Moreover, in recent past central banks of a number of developed countries, like New Zealand and UK, have adopted policies towards direct inflation targeting. In contrast, in countries where the stance of monetary policy has changed more often due to fiscal considerations, a steadfast control on inflationary pressures has remained a difficult task. Against this backdrop this section takes a quick look on the inflationary situation of the Indian economy.

Inflation uncertainty is not a uniform phenomenon over the 25 year span of our study. In fact, from the period 1970-71 to 1994-95, one can discern a number of episodes of inflationary spurts.[6] Given the inflation-averse nature of Indian people and non-hyper-inflationary nature of the Indian economy, if we arbitrarily define a period of inflationary shock as one in which the rate of inflation has exceeded the double digit mark, then during the period under consideration one gets three such periods, *viz*., (i) 1972-73 to 1974-75, (ii) 1979-80 to 1980-81, (iii) 1990-91 to 1992-93.[7] Let us turn to these episodes of inflationary shocks in some detail.[8]

(i) 1972-73 to 1974-75 : During this three year period the average inflation rate stood at 18.5 per cent with an inflation rate of 25.2 per cent during 1974-75, the highest rate of inflation ever experienced in Indian economy in the post independence period till then. Growth too suffered being at an average of 1.8 per cent during this three year period. In fact during 1972-73 for the first time, the Indian economy experienced a negative growth of (–)0.32 per cent – a dubious distinction that was only repeated once more so far. A number of exogenous shocks were responsible for this. *First*, the Indo-Pakistan war of 1971 and related refugee problem of Bangladesh contributed to enormous amount of government expenditure. *Secondly*, the droughts of 1972-73 and 1973-74 caused a marked drop in foodgrain and agricultural production. *Thirdly*, the suspension of US aid in 1972-73 and a marked reduction in foreign aid led to an increased dependence of the Government on borrowing from the Reserve Bank. *Finally*, given the then closed nature of the Indian economy, the

increase in world commodity prices in general and oil price in particular, contributed substantially to inflationary trends.

(ii) 1979-80 to 1980-81 : Though 1979 witnessed a severe drought, in general the two most singularly important causes of inflationary spurt during this period were, increased prices of manufactured goods and fuel. The average rate of inflation during this two year period turned out to be 17.4 per cent – one of the highest experienced so far. Growth rate of real output was (–) 5.2 per cent though within a year it was reversed and turned out to be 7.2 per cent. Despite the 17.1 per cent inflation rate during 1979-80, food prices went up by only 8 per cent whereas the inflation on account of manufactured goods was much higher at nearly 20 per cent, which was caused *inter-alia* by oil price hike.

(iii) 1990-91 to 1992-93 : The third inflationary spurt during our period of study is perhaps too fresh in the memory to be repeated here. Nevertheless, both in terms of inflationary pressures and drop in real growth, this period turned out to be less severe than the earlier two inflationary episodes. Following the gulf crisis, the inflationary tempo of 1989-90 escalated progressively and crossed the double digit mark in 1990-91. Interestingly, this occurred despite a satisfactory agricultural production, the reasons for high inflation are, thus, found in a number of shocks like increases in administered prices of a number of industrial products, hike in procurement and support price of a number of crops, fuel price hike and curtailment of energy quota and rising import costs following the gulf crisis. In the next year too, there was no let-up in inflationary trends – it went further up to 13.74 per cent. Apart from large scale deficit financing, a number of policy induced measures like exchange rate adjustments in July 1991 contributed to it. Nevertheless, during 1992-93 there was deceleration of inflation rate, despite its crossing of double digit mark.

What is the message from these episodes? While the Indian economy is definitely not hyper-inflationary in nature, there are periods when shocks – external or internal – put an upward pressure on prices. Given the extremely low tolerance level of Indian people in so far as inflation is concerned, these shocks get built up into inflationary expectations. This hurts growth to a much large extent than the initial deleterious effect of the original inflationary shocks. This apart, given the large extent of non-indexed wage contracts, in particular in the informal sector, this has regressive impact on distributive front too. Thus, these episodes singularly point out to the role that inflationary shocks can play in affecting the growth rates.

While the above discussion primarily ran in terms of rate of growth and inflation rate nexus, there is reason to believe that often a higher rate of inflation is associated with higher inflation variability. How to measure variability? Let us, purely as an illustrative device define a three-year standard deviation of yearly inflation rates (π) as a proxy for inflation variability for a particular year (denoted by s^{π}).[9] Interestingly, such a rather crude measure of inflation variability has been found to be mildly correlated with the rate of inflation (π) – for the full sample period the simple correlation coefficient between s^{π} and π turns out to be 0.09; on the other hand, the correlation coefficient between real growth rate (g-YR) and inflation rate for the full sample period is (-) 0.39.[10] The correlation coefficient between g-YR and s^{π} too turned out to be negative at (-) 0.26. In fact, the OLS regression between real output growth, inflation and inflation variability for the sample period 1974-75 to 1994-95 (with t-statistics values in parentheses) turns out to be as,[11]

$$(G\text{-}YR)_t = \underset{(4.32)}{5.2349} - \underset{(3.20)}{0.2881\pi_t} + \underset{(3.56)}{0.3096\pi_{t-1}} - \underset{(3.31)}{0.6782(s^{\pi})_t} + \underset{(2.17)}{0.4321(s^{\pi})_{t-1}}$$

with Adj. $R^2 = 0.52$, DW = 2.16, SEE = 2.35

At this point we consider the definition of inflation that is most relevant to our purpose. The official wholesale price index includes a number of commodities, whose prices are administered. Ideally the focus should be on "non-administered" prices, for measuring the market induced price variability, which is the relevant variable for our analysis. Nevertheless, construction of such an index, apart from being fraught with data problems, involves an extremely detailed exercise to take care of both the "direct" and "indirect" impact (*via* the prices of administered commodities which enter as inputs to the non-administered commodities) of administered prices on the prices of non-administered commodities. Where sufficient details are not available, there will have to be data 'adjustments' which could well turn out to be arbitrary, and devoid of any scientific criteria. We have, therefore, desisted from constructing such an index. For purposes of this paper, inflation (denoted by π) is defined on the basis of price of manufactured products which, though, as a group includes some commodities whose prices are administered but would be relatively less influenced by administered pricing than the general WPI. Interestingly, even if we define inflation in terms of price change of manufactured products, the direction of above results remain intact. As for example, the OLS regression between real output growth, inflation and inflation variability with this revised definition of inflation (with t-statistics values in parentheses) turns out to be as,

$$(G\text{-}YR)_t = \underset{(3.16)}{4.2585} - \underset{(1.95)}{0.2138\pi_t} + \underset{(2.84)}{0.2967\pi_{t-1}} - \underset{(2.26)}{0.5155(s^{\pi})_t} + \underset{(1.72)}{0.3897(s^{\pi})_{t-1}}$$

with Adj. $R^2 = 0.51$, DW = 1.79, SEE = 2.64

Thus, there seems to be *prima facie* evidence in favour of the association between g-YR, π and s^{π}. It is to a formal investigation of this association to which we now turn.

Section III

Inflation Uncertainty and Growth : A Methodological Prologue

Earlier Studies on Inflation Uncertainty and Growth

A number of empirical studies have attempted to test Friedman's hypothesis for different countries but have arrived at mixed results. In one of the early studies, Okun (1971), using a sample of seventeen industrial countries, found a high correlation between the average rate of inflation and its variability but a low correlation between inflation variability and growth variability. Katsimbris (1985), however, contradicted this finding, and for a sample of eighteen OECD countries arrived at a positive correlation both between, (a) average rate of inflation and its variability, and (b) variability of industrial production growth rate and the inflation rate. These studies, are, however naive in the sense that variability is defined in terms of some observed standard deviation of inflation data. Using a Lucas (1973) type framework and utilizing rolling regression technique, Froyen and Waud (1987) for a sample of four countries (*viz.*, Canada, UK, US and the then West Germany) arrived at significant cross-country differences in the relationship between inflation uncertainty and level of real output. For Canada and UK, they found evidence of a significant negative output effect for increases in aggregate price uncertainty, however, for West Germany and USA their measures indicated related output effect to be insignificant. While these studies utilised macro data, a number of empirical studies, *e.g.*, Levi and Makin (1980), Mullineaux (1980) or Makin (1982), used Livingstone Survey data for USA in this regard and have found that variance of inflationary expectations across Livingstone Survey respondents is both positively correlated with unanticipated inflation and have a significant negative effect on 'real variables'. The contradictory nature of cross country evidences is either attributed to differences in data sets, estimation routines and methods of generating measures of inflation uncertainty or to an assertion that results differ because authorities in different countries confront the problem of inflation in fundamentally different styles.

A Nested Version of Friedmanite and Lucasian Hypotheses

In his original 1973 formulation Lucas proposed an estimable equation of inflation rates in terms of growth in nominal output, and deviation of growth of real output from its natural rate. However, in discerning the relationship between inflation uncertainty and real growth, following Bohara and Sauer (1992) and Sauer and Bohara (1995), we estimate the following reduced form equation, in the nature of a generalized Lucas Supply function.

$$(g - YR)_t = \alpha + \sum_{i=0}^{n} \beta_i \sigma^{\pi}_{t-i} + \sum_{i=0}^{n} \gamma_i \pi^{ue}_{t-i} + \sum_{i=0}^{n} \delta_i \pi^{e}_{t-i} + u_t \qquad (1)$$

where, (g-YR) is the rate of growth of real output, σ^{π} is a measure of inflation uncertainty, π^e and π^{ue} are anticipated and unanticipated inflation respectively, and u is white noise error term.

The distinction between the rational expectations and Friedman's hypotheses is subtle in the sense that while unanticipated inflation in the former case implies the difference between the actual and anticipated rate, uncertainty in the latter context measures conditional variance of unanticipated rate or the square of one-step ahead forecast error as a percentage of the anticipated rate. Specifically, if unanticipated inflation is viewed as a miscalculation to that extent by agents of the anticipated or forecasted inflation rate for the next period, conditional variance or uncertainty is calculated as the changes in the variance of the unanticipated inflation as a proportion of the anticipated rate.

Time-Varying Parameter Model and Kalman Filtering

All the regresssors in equation (1) *viz.*, σ^{π},π^{e} and π^{ue} are generated ones.[12] The crucial question, therefore, is: how to get estimated measures of σ^{π} and π^{e}? Earlier attempts to define σ^{π} in terms of some observed measure of inflation variability like standard deviation or coefficient of variation of inflation rate does not go well with the theoretical construct of a rational agent who will consider all information available at end of the period t-1, to form expectation at time t. Similarly, defining π^{e} in terms of some regression equation suffers from Lucas critique in the sense that such a specification fails to account for structural breaks and policy shocks. Therefore, in this paper, following Kim and Nelson (1989), we employ a time varying parameter (TVP) model which does not suffer from this limitation and is perfectly consistent with the notion of rational expectations, whereby rational agents update their forecasts periodically and sequentially by adding new information that becomes available at a latter data. In the TVP model a *measurement equation* together with a *transition equation* represent a state-space system. Symbolically, these two equations as a state-space model are represented as follows.

Measurement Equation :

$$\pi_t = Z_{t-1}\,\beta_t + e_t \text{ where, } e_t \sim N\,(0,\sigma^2) \qquad (2)$$

Transition Equation :

$$\beta_t = \Gamma\,\beta_{t-1} + I\,\theta_t : \text{ where, } \theta_t \sim N\,(0,\Omega) \qquad (3)$$

where, Z_{t-1} is the vector of explanatory arguments including a constant term and signifies the information set at time t-1 and used to forecast the next period inflation rate π_t, e_t is the orthogonal measurement error, Γ is a diagonal matrix of autoregressive parameters, θ is a vector of i.i.d normal disturbances with covariance matrix Ω, and I is the identity matrix. The standard properties for the error vector e_t

are assumed to be satisfied. The parameter vector β_t depends only on its past as shown in the transition equation.

The TVP method applied in this study assumes a random walk coefficient variation in the transition equation in order to operationalise the prediction equations. The coefficient or the state vector is accordingly estimated based upon the information available at time t-1. Prediction is carried out by optimising a concentrated likelihood function which brings about a gain in the efficiency of prediction. The use of the likelihood function entails a specification of the conditional initial values of the parameter vector and its variance.[13] We begin by setting up the initial values of coefficients of each independent variable in the measurement equation to be zero, except for lagged dependent variable which is set equal to unity. Since the initial values are provided from outside, there is no loss of observations and Kalman filtering starts operating from the very first observation. The initial conditional values of the elements of the covariance matrix of the state vector is each equal to corresponding estimates of the covariance matrix of the parameter vector computed from a full sample regression of the measurement equation. the standard Kalman filter algorithm then starts and produces generated regressors while passing through corresponding updating and smoothing equations.

A Two-step Procedure

In specific terms, the relationship between inflation uncertainty and real output growth has been investigated through the following two-step procedure.

Step 1 : The TVP model as described by equations (2) and (3) is estimated through Kalman filtering whereby the state vector (here β_t) is estimated in an optimal way and is updated sequentially whenever new observations are available.[14] In particular in our model the current rate of inflation is determined as per the measurement equation in terms of the following variables, (i) growth in nominal GDP, (ii) growth in money stock, (iii) the current price of crude oil, and (iv) one period lagged rate of inflation.[15] Symbolically, the empirically estimable counterparts to the measurement equation and the transition equation are as follows :

$$\pi_t = \beta_{1t} + \beta_{2t}\,(g\text{-}YN)_t + \beta_{3t}\,(g\text{-}M)_t + \beta_{4t}\,(\pi_{OIL})_t + \beta_{5t}\,\pi_{t-1} + e_t\,; \qquad \text{for } M = M_1\,,\, M_3 \quad (2a)$$

$$\beta_{it} = \gamma_i\beta_{i,\,t-1} + \theta_{it}\,; \qquad \text{for } i = 1, \ldots, 5 \quad (3a)$$

where g-x denotes growth rate of the variable x (for x = YN,M). The measurement equation set up above implies that the current rate of inflation is determined by growth in nominal GDP(Y) and money supply (M_1 or M_3) both of which are demand push factors and the current rate of increase in crude prices (π_{OIL}) which is a cost push factor, in addition to a one period lagged rate of inflation itself. The specification of the inflation equation is akin to a simple reaction function of a monetary authority that intends to control the supply of money in order to moderate the rate of inflation but views the information on growth in nominal GDP (demand push) and oil prices (cost push) with equal alarm and equanimity. The presence of π_{OIL} in the measurement equation of inflation rate based on manufacturing prices needs some justification. Even if we take π to be a proxy for non-administered prices, the impact of a price increase in an administered commodity like oil is going to affect non-administered prices as well. Moreover, in the event of an oil price hike, there is every likelihood of an increase in the core inflation of the economy. Consequently, when there is an oil price hike, the long-run inflation rate of the economy may itself go up. The transition equation specifies the dynamic evolution of time varying parameters given the measurement equation and an information set at time t-1. Thus, the three generated regressors are defined as follows :

$$\begin{aligned} \pi_t^e &= (\hat{\pi}_t \mid \beta_t) \\ \pi_t^{ue} &= (\pi_t - \pi_t^e) \qquad (4) \\ \sigma_t^\pi &= \left[\frac{\pi_t^{ue}}{\pi_t^e}\right]^2 \end{aligned}$$

Step 2: Having obtained the values of generated regressors, we then proceed to estimate a generalized Lucas supply function as captured in equation (1).

Section IV
Inflation Uncertainty and Growth in India: The Evidence

In this study annual data from 1970-71 to 1994-95 for annual averages of money stocks (taken to be M_1 and M_3), nominal and real gross domestic product (denoted by YN and YR, respectively), price index of manufactured products (denoted by P) and the rate of inflation based on it (denoted by π), and the index of the average price of crude petroleum (denoted by P_{OIL}) and its relevant inflation rate (denoted by π_{OIL}) are chosen for specifying the model. The empirical results are presented in this study are for both M_1 and M_3 systems wherein alternative measures of money supply are supplanted in the measurement equation.[16]

Behaviour of Generated Regressors

We have already mentioned that three sets of generated regressors have been obtained from a TVP model, using Kalman filters. However, before estimating these generated regressors through a TVP model, we checked the validity of *time-invarying* counterparts of the measurement equations.[17] Though *per se* the equations have a reasonable fit, we preferred to work with the time varying regression due to the theoretical reason that rational agents update their forecasts sequentially using incremental information. One of the basic ingredients of one set of generated regressors *viz.,* unanticipated inflation, is that they have to be white noise. The unanticipated rate of inflation from M_1 [$\pi^{ue}(M_1)$] is white noise since the Box-Ljung chi-square statistic at 8.82 is lower than the 5% critical value of 11.07. The similar Box-Ljung statistic for M_3 system is 5.39. Thus, both π^{ue}'s turn out to be white noise. This is in tune with the notion of the rational expectations hypothesis that rational agents do not make any systematic errors.[19]

Graph A plots the anticipated *vis-a-vis* actual inflation, Graphs B and C depict the intertemporal behaviour of unanticipated inflation and inflation uncertainty, respectively. A look at them confirms our earlier narrative evidence of inflationary shocks in the Indian economy. It is only during the three episodes of inflationary shocks that anticipated inflation diverged substantially from actual inflation, a mirror image of this simple fact is reflected in the sharp edges of the trajectory of unanticipated inflation during these periods.

Generalized Lucas Supply Function:

The empirical counterpart of the second stage Lucas supply regression is presented in Table 1, which throws light on the effects of both inflation uncertainty and unanticipated inflation on the growth of real output. In general, the equations are satisfactory and indicate correctness of functional forms, and absence of serial correlation. Estimates in Table 1 support predominantly Lucasian hypothesis since the coefficient of inflation uncertainty, even through has a correct negative sign, is weakly significant at about twelve percent. However, the estimated value of the coefficient of inflation uncertainty implies that the elasticity of real output with respect to uncertainty is of the order of 0.00597. In other words a one percentage point increase in uncertainty or risk leads to a 0.00597 percentage point fall in real growth. The coefficient of the anticipated rate of inflation in the equation is negative but not strongly significant. The most striking result is the negative and highly significant coefficient of the unanticipated inflation rate, which underscores the validity of the Lucasian hypothesis in its more direct sense. In fact a one per cent increase in unanticipated inflation leads to 0.69 per cent reduction in growth rate.

In case of M_3, however, both the hypotheses are accepted. The coefficient of inflation uncertainty is significant at 4.0 per cent. The estimated coefficient of inflation uncertainty implies that annual real output declines by 0.00873 upon a one percentage point increase in uncertainty. Moreover, the coefficient of unanticipated inflation rate is negative and highly significant, thereby validating the Lucasian hypothesis. In terms of elasticity, a one per cent increase in unanticipated inflation would lead to a 0.62 per cent fall in growth rate. However, like in the case of M_1, the coefficients of the anticipated inflation rate is not significant at the customary level of 5 per cent, implying that rational agents adjust their economic behaviour to minimise output losses.

Since the growth rate of real GDP in India is traditionally influenced by development in the agricultural front, it may be worthwhile to consider the generalised Lucas supply function in terms of rate of growth of GDP originating in non-agricultural sector (g-YRnag). We have therefore, reworked the equations with g-YRnag

Table 1 : Generalised Lucas Supply Function : 1974-75 to 1994-95

Regressors	*M_1 Case*		*M_3 Case*	
	Coefficients	*t-statistics*	*Coefficients*	*t-statistics*
Constant	9.457	5.58 @	9.570	5.58 @
π^e	-0.215	-1.73	-0.240	-1.91
π^{ue}	-0.689	-3.52 @	-0.624	-3.61 @
σ^π	-3.371	-1.60	-4.564	-2.15 #
$(g\text{-}YR)_{t-1}$	-0.565	-2.96 @	-0.478	-2.73 @
Diagnostistics	Adj. R^2 = 0.38 Durbin's h = 1.70 SEE = 2.69 F statistics F(4,18) = 4.39 @ Serial Correlation:LM:$\chi^2(1)$ = 1.01 [0.31] Functional From: LM: $\chi^2(1)$ = 1.45 [0.23]		Adj.R^2 = 0.41 Durbin's h = 0.70 SEE = 2.62 F statistics F(4,18) = 4.88 @ Serial Correlation:LM:$\chi^2(1)$ = 0.25 [0.62] Functional From: LM:$\chi^2(1)$ = 2.17 [0.14]	

Note: The dependent variable is $(g\text{-}YR)_t$
@ and # denote significance at 1 per cent and 5 per cent respectively.
Figures in square brackets are p - values.

as the dependent variable. The results are, more or less, in conformity with the results reported in Table 1.[20]

Evidence from Non-nested Tests

Since there is no a priori reason for superiority of this nested version, we have tried the non-nested version of both the hypotheses separately. Specifically we have run the following equations separately *viz.*,

$$H_F : (g\text{-}YR)_t = \alpha_0 + \beta_0 (\sigma^\pi)_t, \text{ and}$$

$$H_L : (g\text{-}YR)_t = \alpha_1 + \gamma_0 (\pi^{ue})_t + \delta_0 (\pi^e)_t$$

We tried to test the veracity of the two hypotheses in terms of various non-nested tests. The results are given in Table 2.

Table 2: Comparative Performance of the Two Hypotheses

Test Statistics	*M1 Case*		*M3 Case*	
	H_F *against* H_L	H_L *against* H_F	H_F *against* H_L	H_L *against* H_F
1. Davidson-Mackinnon J - Test	2.14	0.56	2.46	1.09
2. Fisher-McAleer JA - Test	0.29	0.56	-0.46	-1.10
3. Encompassing F Test	2.20	0.32	2.91	1.20
4. Akaike's Information Criteria of H_L versus H_F	1.20		1.37	
5. Schwarz's Bayesian Information Criteria of H_L versus H_F	0.61		0.78	

Note : H_F and H_L refer to Friedman's and Lucas's hypothesis, respectively.

The results of the non-nested tests are rather ambiguous for both the hypotheses. The results from Davidson-MacKinnon's J test and encompassing F test indicate superiority of Friedmanian hypothesis over Lucasian hypothesis. Fisher-McAleer JA test, being insignificant for both the models, fails to establish superiority of one model over the other. On the other hand, both AIC and SBIC criteria uniformly favour H_L over H_F, both for M_1 and M_3. The evidence, in a sense, goes well with our preference for nested version of testing both the hypotheses, where at least for M_3 both the hypotheses are found to be valid.

Section V
Conclusion

The empirical results reported in this study indicate that there is little evidence of a trade-off between the anticipated rate of inflation and output growth in the Indian economy. As soon as an anticipation of the future rate of inflation is formulated, there perhaps occurs a rescheduling of aggregate output plan which minimises the adverse fallout of the increasing rate of inflation, a fact which goes in favour of the rational expectations hypothesis. On the other hand, the empirical results are robust enough to indicate an adverse effect of unanticipated inflation on the growth of output. Though Friedman's hypothesis is not strongly supported in the M_1 case, for M_3, inflation uncertainty seems to have a significantly adverse impact on growth. This evidence is in tune with the experience of downturn in real output growth during oil shock episodes of early and late seventies. In terms of policy implications, the study underscores the need for an effective monitoring of the incidence of inflationary shocks and a reduction in its uncertainty in order to mitigate adverse real output effects. Finally, it can be argued that a reduction in the magnitude of the rate of inflation would itself ensure its greater stability and create a favourable climate for sustained economic growth.

Notes

1. See Lucas and Rapping (1969), Lucas (1973), and Barro (1977, 1978) among others.
2. See Fischer (1993), Andersen and Gruen (1995), Barro (1995), and Gutián (1996) among others.
3. Throughout the paper 'variability' and 'uncertainty' are used interchangeably.
4. A number of examples of such structural transformation exist, e.g., bank nationalisation of 1969. However, negligence of the pre-seventies leads to ommission of one episode of inflationary spurt, *viz.*, 1964 to 1966.
5. The coefficients of variation are around sample means.
6. Throughout the paper, the inflation rates are computed on the basis WPI or price index of the manufactured product group (annual average of weekly data, with base 1980-81= 100). Thus, being point-to-point changes in financial year weekly average of price level, inflation rates as per our calculations do not tally with the usual inflation rates that are either point-to-point changes of end of the year-WPI, or average of weekly inflation rates.
7. We are neglecting 1994-95, being the last single year of our sample.
8. While the first two episodes has been discussed in detail in Joshi and Little (1994), see Joshi and Little (1996) for a discussion of the third episode.
9. where, $s_t^\pi = [\frac{1}{3} \sum_{i=0}^{2} (\pi_{t-i} - \bar{\pi}_t)^2]^{\frac{1}{2}}$, and $\bar{\pi}_t = \frac{1}{3} \sum_{i=0}^{2} \pi_{t-i}$
10. This is quite consistent with Barro (1995)'s finding, for 122 countries for the period 1960 to 1990, that an increase in the average inflation rate by 10 percentage points leads to a reduction of real per capita GDP by 0.2 - 0.3 percentage points per year. This is, however, in contrast to Sarel (1996)'s finding for a sample of 87 countries over a twenty year period (1970 to 1990) that when inflation is low, it has no significant effect on economic growth.
11. We have missed few initial observations due our construction of s^π.
12. Of course, given that $\pi^{ue} = \pi - \pi^e$, once we generate π^e, π^{ue} is automatically found out.

13. With $\eta_{t/t-1}$ as the forecast error based on information up to t-1, and $H_{t/t-1}$ as the conditional variance of forecast error ($\eta_{t/t-1}$). The log likelihood function (L) is defined as,

$$\text{constant} - \frac{1}{2} \sum_{t=1}^{T} (\ln | H_{t/t-1} | + \eta'_{t/t-1} H^{-1}_{t/t-1} \eta_{t/t-1})$$

14. The original algorithm is due to Kalman (1960); see Harvey (1989) for details.

15. The specification follows Froyen and Waud (1987). However, our inclusion of the current period's variable in the measurement equation is due to the fact that we use yearly data.

16. Sources for the data are as follows, *viz.*, (i) *National Accounts Statistics*, various Issues [for Incomes data], (ii) Singh, Shetty and Venkatacham (1982) upto 1991-92, and *RBI Report on Currency and Finance*, various issues, thereafter [for average monetary resources], (iii) *Report on Currency and Finance*, RBI, various Issues [for prices data], (iv) *International Financial Statistics*, various issues [for data on oil price index]

17. The *time-invarying* measurement equations for the full sample are as follows (with t-statistics values in parentheses) :

$$\pi_t = -\underset{(1.48)}{6.38} + \underset{(1.70)}{0.38}\,(g\text{-}YN)_t + \underset{(1.62)}{0.44}\,(g\text{-}M1)_t + \underset{(4.64)}{0.06}\,(\pi_{OIL})_t + \underset{(1.34)}{0.23}\,\pi_{t-1};$$

with $R^2 = 0.47$, SEE = 3.67, LM : χ^2 (1) = 0.19

and,

$$\pi_t = -\underset{(1.09))}{10.47} + \underset{(2.35)}{0.50}\,(g\text{-}YN)_t + \underset{(1.04)}{0.53}\,(g\text{-}M_3)_t + \underset{(4.42)}{0.06}\,(\pi_{OIL})_t + \underset{(1.06)}{0.21}\,\pi_{t-1};$$

with $R^2 = 0.57$, SEE = 3.81, LM : χ^2 (1) = 1.21

18. All the generated regressors are reported in Statement 1.

19. See Pesaran (1982) on this issue.

20. The equations with g-YRnag as the dependent variable are as follows,

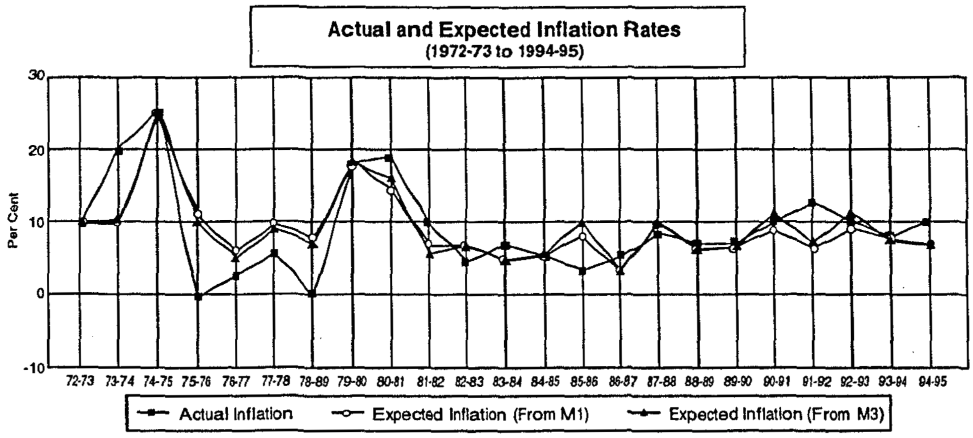
$$(G\text{-}YRnag)_t = \underset{(5.03)}{7.43} - \underset{(2.56)}{0.20}\,[\pi^e (M_1)]_t - \underset{(3.17)}{0.36}\,[\pi^{ue} (M_1)]_t - \underset{(1.01)}{1.35}\,\sigma^{\pi}(M_1)_t + \underset{(0.11)}{0.02}\,(G\text{-}YRnag)_{t-1}$$

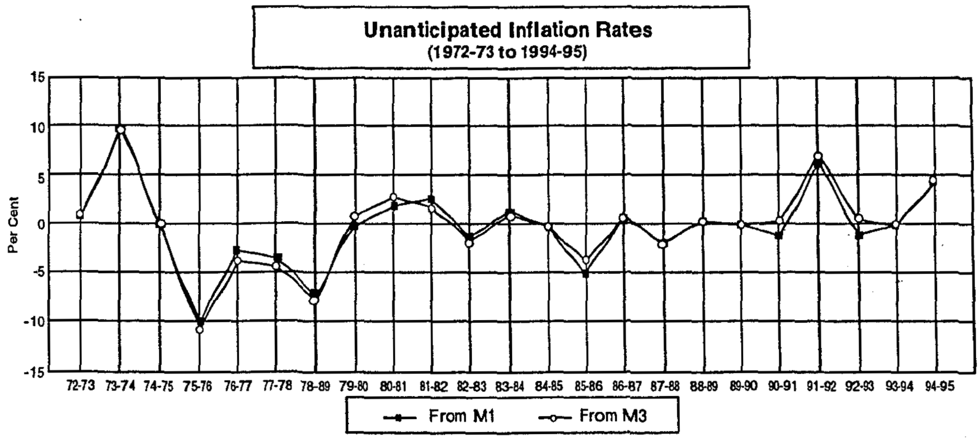
With Adj. $R^2 = 0.41$, F (4,18) = 4.81, h=1.07, SEE = 1.67

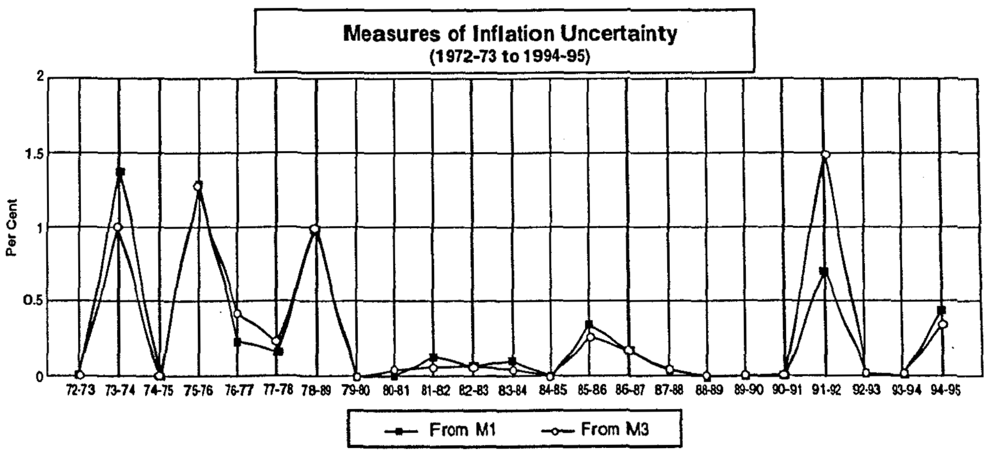
and,
$$(G\text{-}YRnag)_t = \underset{(5.28)}{7.71} - \underset{(2.80)}{0.22}\,[\pi^e (M_1)]_t - \underset{(3.37)}{0.34}\,[\pi^{ue} (M_1)]_t$$

$$- \underset{(1.74)}{2.29}\,\sigma^{\pi}(M_1)_t + \underset{(0.21)}{0.04}\,(G\text{-}YRnag)_{t-1}$$

With Adj. $R^2 = 0.45$, F(4,18) = 5.60, h=0.22, SEE = 1.61


Actual and Expected Inflation Rates
(1972-73 to 1994-95)
Per Cent
30
20
10
0
-10
72-73 73-74 74-75 75-76 76-77 77-78 78-89 79-80 80-81 81-82 82-83 83-84 84-85 85-86 86-87 87-88 88-89 89-90 90-91 91-92 92-93 93-94 94-95
Actual Inflation
Expected Inflation (From M1)
Expected Inflation (From M3)


Unanticipated Inflation Rates
(1972-73 to 1994-95)
Per Cent
15
10
5
0
-5
-10
-15
72-73 73-74 74-75 75-76 76-77 77-78 78-89 79-80 80-81 81-82 82-83 83-84 84-85 85-86 86-87 87-88 88-89 89-90 90-91 91-92 92-93 93-94 94-95
From M1
From M3


Measures of Inflation Uncertainty
(1972-73 to 1994-95)
Per Cent
2
1.5
1
0.5
0
72-73 73-74 74-75 75-76 76-77 77-78 78-89 79-80 80-81 81-82 82-83 83-84 84-85 85-86 86-87 87-88 88-89 89-90 90-91 91-92 92-93 93-94 94-95
From M1
From M3

References

Andersen, Palle and David Gruen (1995): "Macroeconomic Policies and Growth", *Reserve Bank of Australia Research Discussion Paper,* No.RDP 9507

Barro, Robert. J (1977) : "Unanticipated Money Growth and Unemployment in the United States", *American Economic Review,* 67(2) : 101-15.

Barro, Robert. J (1978) : "Unanticipated Money, Output and the Price Level in the United States", *Journal of Political Economy,* 86(4) : 549-80.

Barro, Robert. J (1995) : "Inflation and Economic Growth", *Bank of England Quarterly Bulletin,* 35(2) : 166-176.

Bohara, A.K and C. Sauer (1992) : "Competing Macrohypotheses in the United States", *Applied Economics,* 24 : 389-99.

Choi, Sangmok, Bruce D. Smith, and John H. Boyd (1996): "Inflation, Financial Markets and Capital Formation", *Federal Reserve Bank of St Louis Review,* 78 (3):9-35.

Friedman, M. (1968) : "The Role of Monetary Policy", *American Economic Review,* 58(1) : 1-17.

Friedman, M.(1977) : "Inflation and Unemployment", *Journal of Political Economy,* 85(3) : 451-72.

Froyen, R.T and Waud, R.N.(1987) : "An Examination of Aggregate Price Uncertainty in Four Countries and Some Implications for Real Output", *International Economic Review,* pp. 353-72.

Fischer, Stanley (1993): *Does Macroeconomic Policies Matter? Evidence from Developing Countries,* International Center for Economic Growth Occasional Papers (Number 27), San Francisco: ICS Press.

Guitian, Manuel (1993): "Inflation and Growth: Is There a Trade-Off?, in Manuel Guitian and Robert Mundell (eds.): *Inflation and Growth in China,* Washington, International Monetary Fund.

Harvey, A.C. (1989) : *Forecasting, Structural Time Series Models and the Kalman Filter,* Cambridge : Cambridge University Press.

Joshi, Vijay and I.M.D. Little (1994) : *India : Macroeconomics and Political Economy, 1964-1991,* Delhi : Oxford University Press.

Joshi, Vijay and I.M.D. Little (1996) : *India's Economic Reforms, 1991-2001,* Delhi : Oxford University Press.

Kalman, R.E (1968) : "A New Approach to Linear Filtering and Prediction Problems", *Journal of Basic Engineering,* (Transactions of ASME, Series D), pp.35-45.

Katsimbris, George. M (1985) : "The Relationship between Inflation Rate, Its Variability, and Output Growth Variability", *Journal of Money, Credit and Banking,* 17(2) : 170-188.

Kim, C-J, and C.R. Nelson (1989) : "The Time-Varying Parameter Model for Modelling Conditional Variance: The Case of the Lucas Hypothesis", *Journal of Business and Economic Statistics*, (October) 433-40.

Levi, Maurice P., and J.M. Makin (1990) : "Inflation Uncertainty and the Phillips Curve : Some Empirical Evidence", *American Economic Review*, 70 : 1022-27.

Lucas, R.E., Jr (1973) : "Some International Evidence on Output-Inflation Tradeoffs", *American Economic Review*, 63 : 326-34.

___ and L.A. Rapping (1969): "Price Expectation and the Phillips Curve", *American Economic Review*, 59(3): 342-50.

Makin, J.H. (1982) : "Anticipated Money, Inflation Uncertainty and Real Economic Activity", *Review of Economics and Statistics*, 126-34.

Mullineaux, D.J (1980) : "Unemployment, Industrial Production, and Inflation Uncertainty in the United States", *Review of Economics and Statistics*, 163-69.

Okun, Arthur. M (1971) : "The Mirage of Steady Inflation", *Brookings Papers of Economic Activity*, (2) : 485-98.

Pesaran, M.H.(1982) : "A Critique of the Proposed Tests of the Natural Rate-Rational Expectations Hypothesis", *Economic Journal*, 92 : 529-554.

Sarel, M.(1996) : "Nonlinear Effects of Inflation on Economic Growth", *IMF Staff Papers*, 43 : 199-215.

Sauer, C. and Alok K. Bohara (1995): "Monetary Policy and Inflation Uncertainty in the United States and Germany", *Southern Economic Journal*, 62:

Singh, Anoop, S.L.Shetty, and T.R. Venkatachalam (1982) : "Monetary Policy in India : Issues and Evidence", *RBI Occasional Papers*, (Supplement), 3(1) : 1 - 133.

Tobin, James (1955): "A Dynamic Aggregative Model", *Journal of Political Economy*, 63:103-15.

Tobin, James (1965): "Money and Economic Growth", *Econometrica*, 33:671-84.

Statement 1 : Generated Regressors obtained through Kalman Filtering

Year	Derived for M_1			Derived for M_3		
	Expected Inflation	Unexpected Inflation	Inflation Uncertainty	Expected Inflation	Unexpected Inflation	Inflation Uncertainty
	$(\pi^e)_{M_1}$	$(\pi^{ue})_{M_1}$	$(\sigma^\pi)_{M_1}$	$(\pi^e)_{M_3}$	$(\pi^{ue})_{M_3}$	$(\sigma^\pi)_{M_3}$
1972-73	5.60	5.77	1.06	5.80	5.58	0.92
1973-74	13.26	1.16	0.01	14.51	-0.08	0.00
1974-75	24.41	-3.43	0.02	24.50	-3.52	0.02
1975-76	3.17	-1.75	0.31	3.34	-1.92	0.33
1976-77	3.27	-0.90	0.08	4.87	-2.50	0.26
1977-78	6.56	-4.31	0.43	8.40	-6.14	0.54
1978-79	4.98	-4.85	0.95	4.69	-4.56	0.94
1979-80	13.19	6.91	0.27	12.69	7.40	0.34
1980-81	12.77	6.63	0.27	13.51	5.89	0.19
1981-82	10.84	-5.04	0.22	11.12	-5.32	0.23
1982-83	3.73	-0.23	0.00	3.57	-0.07	0.00
1983-84	6.90	-0.81	0.01	7.55	-1.46	0.04
1984-85	7.55	-0.54	0.01	6.35	0.66	0.01
1985-86	5.77	0.10	0.00	5.95	-0.07	0.00
1986-87	2.83	1.03	0.13	2.82	1.04	0.14
1987-88	7.87	-0.67	0.01	7.92	-0.72	0.01
1988-89	8.23	1.23	0.02	8.88	0.58	0.00
1989-90	11.94	-0.73	0.00	11.23	-0.01	0.00
1990-91	11.92	-3.49	0.09	10.84	-2.42	0.05
1991-92	9.14	2.13	0.05	7.29	3.98	0.30
1992-93	8.34	2.58	0.10	8.67	2.24	0.07
1993-94	7.06	0.74	0.01	7.21	0.59	0.01
1994-95	12.48	-1.95	0.02	10.50	0.02	0.00

Note : For definition and derivation of the variables see text.

Reserve Bank of India Occasional Papers
Vol. 17, No. 4, December 1996

Pricing Yield Curve Swaps : An Application To Indian Bond Market

A. Prasad*

Corporates and banks in India have limited access to derivative instruments for their foreign currency exposure. The deregulation of interest rates has resulted in increased risk, heightened the concern for risk cover and created the need for proper strategies for asset-liability management. An attempt has been made in this paper to price a yield curve swap in the Indian bond market using the Black, Derman and Toy model. The paper notes that the absence of a deep and liquid domestic term money market acts as a major impediment to the orderly development of a rupee derivatives market in India.

Introduction

An interest rate swap is a contractual agreement between two parties to exchange a series of payments for a stated period of time. When combined with an asset or a liability, a swap can change its risk characteristic by changing the net cash flow. For instance, a fixed rate liability can be converted to a floating rate liability. Prior to 1980, borrowers typically matched their financial needs in terms of maturity, currency and whether the interest rate was fixed or floating. In other cases, the borrower accepted the risk or inconvenience due to any mismatch between what was required and what was obtained, either because the borrower had no other choice or because there was a trade-off between mismatch and lower funding cost. Soon, financial institutions discovered that, depending upon their credit rating, they had comparative advantage in different markets. That is, the credit spread between higher and lower-rated institutions for fixed

* Dr. A. Prasad is Assistant Adviser in Department of Economic Analysis and Policy, presently attached to the Secretary's Department. The original version of the study was prepared as part of the MBA program in the Katz Graduate School of Business, University of Pittsburgh, USA. The author owes a deep sense of gratitude to Dr.Raw Ren Chen, visiting Professor from Rutgers University to the University of Pittsburgh, under whose close guidance this study was prepared. Thanks are due to Dr.Sanjay Srivastava, Professor, Carnegie Mellon University for his time spent on the technical and conceptual aspects of the study. The author also wishes to express his thanks to Mr.Kumar Ladha for his extensive help on the computational aspects of the original version. The author is responsible for any errors that may remain.

rate borrowings is wider than the corresponding spread for floating rate borrowings. In other words, the lower-rated borrower has a relative or comparative advantage over the higher-rated borrower in the floating rate market. Conversely, the higher-rated borrower has the relative advantage in the fixed rate market. If each borrower raises funds in the market in which it has greater comparative advantage, then the corresponding interest payments can be swapped to achieve cheaper funding rates for both.

The most basic swap involves the conversion of interest rate payments based on a floating rate of interest into payments based on fixed rate (or vice versa), called the vanilla swap. Basic swaps have branched into many variants, each geared towards meeting specific customer needs in various markets. This paper attempts to price yield curve swaps by using the Black, Derman and Toy model (1990) for forecasting future short rates. A related objective of this paper is to study the impact of volatility on the swap premium. The paper is organized as follows. Section I traces the evolution of the swap market. Section II elucidates the features and typical applications of many variants of the basic vanilla swap. Section III describes the features of the yield curve swap and determines the swap premium for a three-month swap against one-year swap. A one-factor model of interest rates (Black, Derman and Toy or BDT model) is constructed and applied to determine the swap premium. The BDT model is thereafter used to determine simple European option prices under different assumptions of strike prices. Section IV studies the impact of different volatilities on the swap premium. The impact of volatility on simple option prices is compared with the impact of volatility on swap premium to determine the good fit of the model. Finally Section V experiments with the BDT model for pricing yield curve swaps (or coupon swaps) using the Indian yield and volatility curves.

Section I

Evolution of the Swap Market

Swaps are essentially agreements between two counterparties to exchange cash flows (which are usually exchanges of interest rate obligations but sometimes also the principal as in the case of currency swaps) undertaken for the mutual benefit of the parties concerned.

Depending upon the type of cash flows exchanged, swaps are classified into *interest rate, currency, and cross-currency interest rate* swaps. In the classic interest rate swap, the parties exchange fixed rate for floating rate cash flows in the same currency. In a currency swap, the parties exchange cash flows expressed in different currencies, while in a cross-currency interest rate swap, the parties transform both the currency and the type of cash flows exchanged. The swap market has grown from a negligible volume in the early 1980s to total swaps outstanding of approximately US$4.6 trillion as of 1992. Total annual volume is also currently significant, running at around US$3.5 trillion per annum.[1]

In the currency area, swaps reduce the risks that are associated with trade finance and provide an important asset/liability management technique in international business more effectively than some other traditional hedging alternatives. For the importer or exporter with foreign currency payable or receivable, swaps offer advantages in increased certainty and lower cost over alternatives such as offshore funding, leads or lags in payments, or short-term hedges in the forward foreign exchange markets. Swaps, moreover, accomplish these purposes without the destabilizing effects on the foreign currency market or the added capital market access requirements associated with the comparatively awkward techniques that were previously available.

Development of the Swap Market

The key factors which have influenced the development and evolution of the swap market include the following :

- regulations and the regulatory environment – which created opportunities for capital market arbitrage;
- volatility of key financial market variables, such as interest rates, exchange rates, commodity and equity prices – which prompted increased emphasis on risk management;
- the internationalization of financial markets – which facilitated globalisation of fund raising and investing activity;
- the regulation of the swap market itself through the BIS capital adequacy requirement - which affected the capacity of financial institutions to participate as intermediaries in swap transactions;
- the competitive market structure – which dictated the

participation of financial institutions in the global swap markets and influenced the development in complementary markets for derivative products generally.

Of course, interest rate swap is not the only instrument used to manage risk. A number of asset-liability management tools have been developed, such as financial futures contracts, options, and other over-the-counter products. Yet among all these, interest rate swap is perhaps the most flexible and versatile instrument available for hedging interest rate risk.

The evolution of the swap market can be delineated into three periods :

- The period between the 1970s to 1982-83 was characterized by low transaction volumes, limited product knowledge, highly structured transactions involving counterparties with exactly matching and opposite requirements, and the absence of a definitive framework for pricing, accounting and taxing of such transactions.
- The second phase of the evolution of the swap market covering the period 1983 to 1988-89 can be characterized as the growth period. This period entailed an unprecedented and extraordinary level of growth in the swap market. This period witnessed the expansion of swap applications due to asset-liability management, development of new liability swap structures, and the secondary market for swaps. The number of swap market participants and end users began to utilize the swap market in order to obtain low-cost financing, create high-yield assets and to hedge interest rate or currency exposure generated from the structure of normal business. Speculation increased during the period.
- The swap market entered the maturity stage in 1989. The post-1989 period witnessed a broad range of swap financing instruments covering both asset and liability management applications.

Section II

Variations To Basic Interest Rate Swaps

The standard interest rate swap consists of the exchange of a floating rate payment stream for a fixed rate payment stream. The agreement has a fixed maturity and the notional amount is held constant throughout the life of the swap. The underlying structure of the generic interest rate swap has been modified in a variety of ways in order to accommodate alternative applications.

Variations to Coupon Payments

Off-Market Swaps

The swap is so structured that the value of the fixed rate side, including a possible up front payment, just equals the value of the floating rate side under current market conditions, and the net value of the swap is zero. Any change in the market rates, or just the passage of time, can cause a deviation in the value of the swap. If a new swap is off-market, then a compensating upfront payment from one party to the other will be required to bring the net value to zero. Thus, off-market structures may involve oddly-dated or sized cash payments between the parties, the setting of a lower or higher than market coupon on the fixed pay leg, a spread added to or subtracted from the floating leg, or some combination thereof.

Non-LIBOR Swaps

Approximately 90 per cent of all swaps use LIBOR as the floating rate basis for the transaction. However, a swap counterparty may wish to pay (or receive) some other floating index, such as Commercial Paper, the Prime Rate or Treasury Bills (T-Bills). A non-LIBOR floating rate index often appears in swaps used to manage basis risk. Basis risk refers to the possibility that the yield differential between two floating rate indices changes over time. For example, a bank may have floating rate assets (loans) whose interest receipts fluctuate based on the prime rate. This same bank may have liabilities (funding) whose interest payments fluctuate based on LIBOR. Bank management has the choice of accepting the risk that the basis of its assets does not match the basis of its liabilities, or it can choose to manage the basis risk by using a basis swap.

Basis Swaps

These are also called Floating-for-Floating swaps. In one form, the two sides of the swap are tied to different floating rates. For example, one side might be tied to six-month LIBOR while the other might be tied to six-month Certificate of Deposit or Commercial Paper rate. In the second form, the two sides of the swap might be tied to the same pricing vehicle but with different payment frequencies. For example, one side might involve semi-annual payments based on six-month LIBOR while the other might involve payments based on one-month LIBOR. This study deals with the pricing of a three-month T-Bill and a one-year T-Bond. A third variant incorporates both of the first two. For example, one side might involve monthly payments priced on one-month LIBOR while the other might involve semi-annual payments calculated on six-month Certificate of Deposit rate.

Zero Coupon Swaps

In general, payments are netted between the counterparties on the least frequent reset leg of the swap. A zero coupon swap is an extreme case of an off-market swap in which one of the counterparties makes a lump sum payment instead of periodic payments over time. These swaps are attractive to corporate users who themselves hold zero coupon assets but who pay floating rate on their liabilities (and *vice-versa*). For example, a buyer or owner of a zero coupon bond can create a synthetic security that converts the zero coupon bond into a LIBOR-floating rate bond or a semi-annual fixed coupon bond.

Prepaid Swaps

In contrast to the zero coupon swap, in a prepaid swap, the future payments due under a leg (usually those under the fixed-payment leg) are discounted to a present value and paid at the start of the swap. The prepaid swap is analogous to the annuity. The premium paid for the annuity is the prepaid fixed leg, and the payments under the annuity contract are the variable payments under the floating leg of the swap.

Step-Up Swaps

Sometimes, a swap on the fixed side has a series of fixed rates applied to non-overlapping time intervals. Thus, even though all payments are known, they are not equal. These swaps are called step-up or step-down coupon swaps depending upon the structure. They are mainly used to manage cash flow needs and constraints effectively.

Asset Swaps

Swaps are used not only for managing liabilities, but also for engineering the cash flows from assets into desired formats. The term synthetic security refers to the use of swaps and derivative swap products to alter the characteristics of a fixed-income asset. The most common structure is the alteration of a fixed rate security to a floating-rate security (or *vice-versa*), thereby making the security of value to a new fixed-income investor. Alterations could also be accomplished in the timing of the asset's payments or the currency denomination of its cash flows.

Forward and Extension Swaps

Forward Swaps

A forward swap is one in which there is a significant delay between the date on which the swap is traded or committed to and the settlement or effective date of the swap. In contrast to a swap option, a forward swap offers the opportunity to lock in a fixed rate today, either as a fixed rate payer or receiver, but have payments under the swap begin at a future date.[2] In addition, because the swap market is fairly liquid, forward swaps are flexible and can be unwound at any time before or after the swap commencement date, should requirements change.

Extension Swaps

The term extension swap refers to an interest rate swap product that effectively extends the maturity of an existing interest rate swap. An extension swap enables counterparties that have interest rate swaps already on their books to take advantage of current rates and lengthen the maturity of their swaps, thereby hedging future exposure to adverse changes in future fixed swap rates.

Variations on Notional Principal

Amortizing Swaps

Usually, the notional or principal amount of the swap is held constant throughout the life of the swap. However, situations might arise in which there is a need for varying the notional principal. In amortizing swaps, the notional principal starts at a high level and gradually decreases. An amortizing swap is suitable when the asset or liability being hedged is itself amortizing. Amortizing swaps are typically used in conjunction with mortgage loans, mortgage backed-securities and automobile- and credit-card backed securities. All of these tend to involve repayment of principal over time.

Accreting Swaps

The flip side of an amortizing swap is an accreting swap, which as the name suggests, allows the notional principal to accumulate during the life of the swap. The accreting swap arises commonly with construction finance, in which a construction company has a floating rate draw-down facility with a bank. That is, a line of credit may be tapped that would lead to increasing amounts of floating rate borrowing. One alternative is to enter into a series of interest rate swaps, as and when the loan is drawn down. An acceptable alternative is to enter into an accreting interest rate swap with the notional principal increasing in step with the planned draw-down of the loan.

Seasonal or Roller Coaster Swaps

Amortizing and accreting notional principals can be combined to form a seasonal swap, which allows the notional principal to vary according to the counterparty's seasonal borrowing needs such as those retailers typically experience. A swap that allows for periodic or arbitrary but predictable swings in notional principal is called a roller coaster.

Swaptions

There are certain risks inherent in mismatches of principal with notional principal in amortizing swaps. The amount of principal is not always perfectly predictable, particularly for many new types of asset-backed securities. Option contracts are designed to handle contingencies of this kind, and a market has developed for options on swaps, known as swaptions. Like any option, swaptions entail a right and not an obligation on the part of the buyer. The simplest example involves the buyer paying a premium in order to have the right, but not the obligation, to enter into an interest rate swap at a predetermined interest rate at a specified future date. The buyer will exercise the option only if the rate is favourable on the exercise date compared with the rate prevailing for an identical interest rate swap in the market on that date. A call swaption is the right, but not the obligation to buy a swap – to receive a fixed rate and pay a floating rate. The put swaption is the right but not the obligation to pay a specific fixed rate in a swap and receive the floating rate. The swaption on the plain vanilla swap is the most common, although swaptions can be written on more complicated swaps. Both the maturity of the swaption and the tenor of the underlying swap, which commences at a stipulated future date, must be specified. Also like options, swaptions come in both American and European varieties.

Section III

Pricing of Yield Curve Swaps

Yield Curve Swaps – Features

These are swaps on which both legs are floating but, unlike basis swaps, the floating legs may be tied to two ends of the same instrument. Usually, in the basis swap, the counterparty pays (receives) US $ LIBOR and receives (pays) the ten-year or thirty-year Treasury yield plus/minus a spread. Both rates are reset either quarterly or semi-annually and the term of the yield curve swap ranges from three to ten years. Yield curve swaps are generally insensitive to the absolute level of interest rates and very sensitive to the shape of the yield curve.

Yield curve swaps create an exposure to the slope of the yield curve. Under a typical arrangement, where the counterparty receives the 10 or 30 year treasury yield and pays a 3-month yield on the same yield curve, if the yield curve steepens, its net receipt will increase. Conversely, if the yield curve flattens or inverts, the net receipt will decrease. Yield curve swaps developed rapidly to become commonly utilized products, particularly among investors in the US $ swap market. A number of variations to the standard yield curve swap structure have also emerged; for instance, both parties pay floating rates of interest based on different floating rate indices.

In this study, a yield curve swap has been defined as an interest rate swap between a three-month Treasury Bill (T-Bill) rate and one-year Treasury Bond rate, (i.e.) both parties pay floating rate of interest based on the same index. Two issues are relevant here. First, the spread between the 3-month and 1-year interest rate in the base case scenario is only 53 basis points. In reality, such a small spread may not induce participants to enter into an interest rate swap. Secondly, an ideal yield curve swap would be the exchange of interest flows between a 3-month and 10-year rate payers (receivers). However, considering the limitations of the Excel solver, the concept has been demonstrated on a 3-month against a 1-year swap. The economic structure of yield curve swaps is driven, largely by the shape of the yield curve in the relevant currency. The pricing of such transactions derives from implicit forward rates embodied in the yield curve. In effect, the transaction pricing is generated by calculating the implied term forward interest rates relative (one year rate in intervals of three months) to the implied three-month rates in the same yield curve. The interaction of these two sets of implied forward rates determines the margin above or below the term interest rate component of the yield curve swap.

Choice of Interest Rate Model

The literature on interest rate models originated with the Cox-Ingersoll-Ross model (CIR)[3] who assumed that the short rate follows a mean reverting process.[4] However, this model assumes that the whole term structure depends on a single stochastic variable or factor. Ho and Lee were the first to offer a stochastic interest rate model that exactly matched the observable term structure of interest rates. The authors realized that a model would be useless if it cannot fit the yield curve. Any error in the fitting of the yield curve can cause significant consequences in pricing derivatives. The authors took the term structures as given, i.e., instead of pricing bonds, they took bond prices as given. The Ho and Lee model has the advantage that it is easy to apply and provides an exact fit to the current term structure of interest rates.[5] One disadvantage of the model is that it gives the user very little flexibility in choosing the volatility structure. All spot and forward rates have the same instantaneous standard deviation. Another relative disadvantage of the model is that it has no mean reversion. This means that regardless of how high or low interest rates are at a particular point in time, the average direction in which interest rates move over the next short period is always the same. Black, Derman and Toy (BDT) extended the Ho and Lee model to match the term structure of volatility curves in addition to the term structure of interest rates.[6] The distribution assumption of the short rate is lognormally distributed. This study is an application of the BDT model to the pricing of yield curve swaps. The forward induction procedures provided by Jamshidian has been used for the efficient construction of the binomial tree for the interest rate structure.

Black, Derman and Toy Model – Methodology For Estimation of Future Short Rates

In this simple versatile model of interest rates, all security prices and rates depend on the short rates. The current structure of long rates and their assumed volatilities are used to construct a tree of possible future short rates. The tree is then used to price yield curve swaps.

The model has three key features :

- The fundamental variable is the short rate – the annualized three month US Treasury Bill yield to maturity (YTM).[7] This is the "one factor" of the model. A change in this factor drives all security prices.
- The model takes as inputs an array of yields on Treasury Bonds up to 2 years for various maturities and an array of yield volatilities for the same bonds. The authors, in the original article, call the first array the yield curve and the second the volatility curve. Since one of the objectives of the paper is to study the impact of changes in volatility on the swap premium, different volatility curves have been assumed for the same yield curve. No attempt has been made, for the purpose of this study, to estimate actual volatility.[8] The initial scenario of yield curve and volatility curve is given below :

Table – I

Term Structure of Yields and Volatility : Base Case Scenario

Period	*Yield To Maturity*	*Annual Volatility*	*De-Annualized 3-Month Volatility*
3 Month	5.11%	8.00%	N/A
6 Month	5.29%	8.25%	4.13%
9 Month	5.47%	8.50%	6.01%
12 Month	5.64%	8.75%	7.58%
15 Month	5.92%	9.00%	9.00%
18 Month	6.00%	9.25%	10.34%
21 Month	6.10%	9.50%	11.64%
24 Month	6.12%	9.75%	12.90%

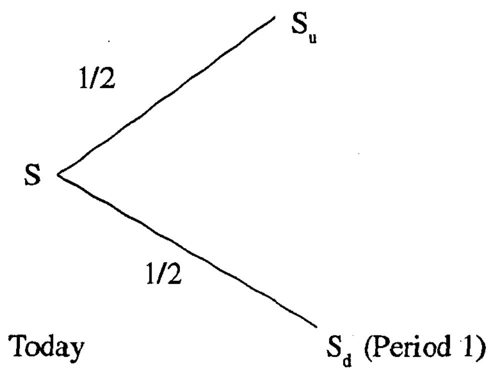
- The array of volatilities are varied (the actual YTMs are kept constant) for the future short rates to match the inputs. As the future volatility changes, the mean reversion changes.

The BDT model assumes a binomial evaluation of the short rate. The risk-neutral probabilities for the up and down movements are fixed at 0.50 each.[9] They adjust both the up and down movements to assure the perfect matches on the bond prices and volatilities. The three-month bond price is certain because the three-month interest rate is known. A discrete discounting with 5.11 per cent (annualized three-month rate) gives a price of \$0.987617987 for a Zero-Coupon Bond (ZCB) maturing in three months with a face value of \$1. The six-month YTM is an annualized 5.29 per cent. The six-month bond price, obtained by discretely discounting the face value of \$1 at 5.29 per cent is \$0.974555187. We know that this price, P(0,2) also equals[10] :

$$\frac{1}{2} [\, P(0,1,2) + P(1,1,2)\,] \times P(0,1)$$

$$0.974555187 = \frac{1}{2} \left[\frac{1}{1+r10} + \frac{1}{1+r11} \right] \times \$0.987617987 \quad \text{................ (1)}$$

The logic for the above calculation is the following. Consider an interest-rate sensitive security worth S today. We assume in this model that its price can move up to S_u or down to S_d with equal probability over the next time period. The following figure shows the possible changes in S for a one-period time step (BDT assumed a one-year period in their original article), starting from a state where the short rate is r.



The expected price of S one year from now is $\frac{1}{2}(S_u + S_d)$. The expected return is $\frac{1}{2}(S_u + S_d) \div S$. The models assumes that the expected returns on all securities over one period are equal and that money can be lent at r. Thus we can deduce

$$S = (\frac{1}{2} S_u + \frac{1}{2} S_d) \div (1 + r), \text{ where r is today's short rate.}$$

The one-step tree can be used to relate today's prices to the prices one period ahead. Similarly, prices one period in the future can be derived from prices two periods in the future. In this way, prices today can be related to prices two periods away.

However, to solve for the two interest rates in equation (1), we need another equation. The second equation represents the volatility structure. In the Cox-Ross-Rubinstein binomial model the up and down are characterized by[11]

$$u = e^{\sigma \sqrt{\Delta t}}$$

$$d = e^{-\sigma \sqrt{\Delta t}}$$

σ is the volatility of the two-period (in our case six-month) yield which is defined as

$$\sigma_1 = \ln \left[\left(\frac{1}{P(1,1,2)} - 1\right) \div \left(\frac{1}{P(0,1,2)} - 1\right)\right] \div 2 \quad \text{.........................} \quad (2)$$

$= 8.25$ percent (Table - 1)

The de-annualised three-month volatility = $\sqrt{25}$ x 8.25 = 4.13 per cent.

Solving the simultaneous equations using the Excel solver, we obtain the following results.

r_{11} = 1.3957 per cent (the annualized rate works out to 5.5828 per cent)

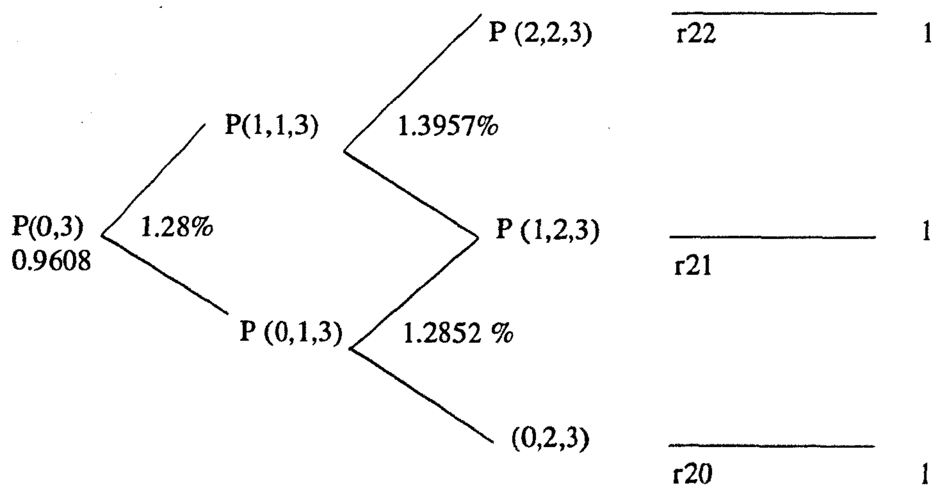
r_{10} = 1.2852 per cent (the annualized rate works out to 5.1408 per cent).

This implies that the two bond prices are :

$$P\ (1,1,2) = \frac{1}{1+r11} = \frac{1}{1+3.957\%} = \$0.986235341$$

$$P\ (0,1,2) = \frac{1}{1+r10} = \frac{1}{1+2.852\%} = \$0.987311514$$

Extending the same model for the three period bond, we first determine its price by using the nine-month yield (5.47 per cent). This turns out to be \$0.960844903.



The bond price can be obtained by discounting the payoff.

$$P(0,3) = [\frac{1}{2}P(1,1,3) + \frac{1}{2}P(0,1,3)] \div (1 + 1.28\,\%)$$

$$= \frac{1}{1.0128\%} \times \frac{1}{2} \; [\{\frac{1}{2} \times P(2,2,3)\} + \{\frac{1}{2} \times \frac{P(1,2,3)}{1.013957}\}] +$$

$$[\{\frac{1}{2} \times P(1,2,3)\} + \{\frac{1}{2} \times \frac{P(0,2,3)}{1.012852}\}]$$

$$= \frac{1}{1.28\%} \times \frac{1}{4} \times \frac{(1+r22)+(1+r21)}{1.03957} + \frac{(1+r21)+(1+r20)}{1.012852}$$

The interest rate structure for this period should match the volatility structure. The volatility for the second period (σ 0,3) is equal to :

$$\ln((\sqrt[2]{(1/P(1,1,3)-1}) \div (\sqrt[2]{1/P(0,1,3)-1})) \div 2$$

= 8.50 per cent.

The de-annualised volatility equals

$$\sqrt{0.50} \times 8.50$$

= 6.01 per cent.

In addition, the following constraints are set :

$$\ln\frac{r22}{r21} = \ln\frac{r21}{r20}$$

Solving the equations using the Excel solver, we obtain 1.6492 per cent, 1.4101 per cent and 1.2056 per cent as the interest rates in the second period. The interest rate tree for yield curve and volatility curve depicted for the base case scenario as depicted above is presented in Exhibit I.[12]

Pricing of Yield Curve Swaps – Framework

Yield curve swaps represent a contract in which both legs of the swap commit to floating interest rates. This swap will involve an initial exchange of cash flow (premium) since there exists no fixed coupon rate. For the purpose of this study, the premium is defined as the initial exchange of cash flow which the three-month interest rate payer will pay the one-year interest rate payer. The BDT methodology is used to determine the premium. The settlement will be done in US dollars and it is assumed that there will be no default. The initial premium is determined for the yield curve which matches the 8.0 per cent volatility curve with a step-up of 0.25 percentage points.

The annualized three-month forward interest rates have already been determined through the BDT model. At each node, it is now necessary to determine the one-year interest rate. This can be easily determined from Exhibit-II, which shows bond prices. The one-year rate at r_{11} and r_{10} can be determined from the up and down prices of the 15-month bond at this point. This will equal :

$- \ln P(1,1,4) = - \ln (0.9373076) = 6.47$ per cent, and
$- \ln P(0,1,4) = - \ln (0.9472896) = 5.42$ per cent.

The annualized three-month and 12-month swap rate tree calculated in the above manner are presented in Exhibit - III.[13] The interest rate differential at each node in the tree represents the rate which the three-month rate payer would be required to pay the 12-month rate payer. The differential rate is converted into the swap premium tree in the following manner :

$$\text{Premium} = \Delta r \times \text{notional principal.}$$

The present value of the premium is thereafter obtained by discounting the premiums at each point by the forward three-month interest rate calculated at each node, i.e.,

$$\text{Present value of premium} = \frac{Premium}{1 + r}$$

The swap-premium and the present value of the swap trees are depicted in Exhibits IV and V. For the yield curve and volatility curve assumed above, the present value of the swap premium, i.e., the premium that the three-month rate payer will pay the one-year rate payer upfront works out to $96,882.90, or 0.9688 per cent of the notional principal.

Section IV

The Impact of Volatility on Swap Premium

In all, three scenarios of interest rates were estimated, using the same yield curve but different volatility curves. The volatilities were assumed to be 8 per cent, 12 per cent and 4 per cent and under each of these scenarios, volatility was assumed to move up and down, respectively, by 0.25 percentage points in each period. Thus, in all, six interest rate scenarios were postulated. Repeating the procedures described above, the forward interest rates were calculated by matching yields and volatilities, and based on this, the swap premiums were determined. The swap premiums under the different scenarios are summarized in the following table :

Table - II

Swap Premiums under Different Volatility Curve Scenarios

Volatility (%) (Assumed)	*Swap Premium (US $)*	*Swap Premium (% to capital)*
8.0 (Step-up .25 % points)	96,882.90	0.9688
12.0 (Step-up .25 % points)	103,468.61	1.0347
4.0 (Step-up .25 % points)	92,730.25	0.9273
8.0 (Step-down .25 % points)	94,099.26	0.9410
12.0 (Step-down .25 % points)	99,163.37	0.9916
4.0 (Step-down .25 % points)	91,364.18	0.9136

The impact of volatility on swap premiums can be discerned from the above Table in the following manner :

Base Volatility : 8.0 Per cent Step-up : 0.25 percentage points

- When base volatility is increased by 4 percentage points to 12.0 per cent, the premium increases by 6.8 per cent to $ 103,468.61.
- When base volatility is decreased by 4 percentage points to 4.0 per cent, the premium decreases by 4.29 per cent to $92,730.83

Base Volatility : 8.0 per cent Step-down : 0.25 percentage points

- When base volatility increases by 4 percentage points to 12.0 per cent, the premium increases by a lower rate of 5.4 per cent to $99,163.37 (as compared to the step-up scenario).
- When base volatility decreases by 4 percentage points to 12.0 per cent, the premium decreases by a lower rate of 2.91 per cent to $91,364.18 (as compared with the step-up scenario).

We may therefore, generalize the findings of the above contract in the following way :

- Overall, the impact of volatility on the swap premium in respect of a yield curve swap is modest.
- The impact on the swap premium is much greater when the volatility curve is rising than when it is declining.

The model however, raises an important question regarding the swap premium, that is, whether the model has correctly priced the swap premium itself. In the absence of comparable prices (since each contract is unique), one cannot be sure of the correctness of the pricing itself. For instance, in Exhibit 1, the model estimates the future spot rate on the upside and downside at 22.86 per cent and 1.25 per cent, respectively. In another scenario, where the volatility is assumed to be 12.0 per cent with a step-up of 0.25 percentage points, the estimates turn out to be more unrealistic. The future spot rates on the upside are as high as 35.68 per cent and that on downside are as low as 0.63 per cent. A look at the interest rate and pricing trees indicate that the future cash flows are diverging rapidly. In actual practice, this may not be the case. Another major problem is that volatility itself is not observable. The implied future volatility changes over time and since volatility for the future term structure is estimated at the point of entering into an agreement, there could be a tendency to either overestimate or underestimate volatility. This will alter the interest rate structure and affect the swap premium.

One difficulty in comparing the impact of volatility is the lack of a suitable benchmark. In order to find out whether the swap premiums are on track and whether the impact of volatility on the premiums are reasonable, simple European options were priced on the BDT tree. By studying the difference in option prices on different assumptions of strike rate under different interest rate scenarios, one might be able to compare the reasonableness of the swap premiums. The option prices were calculated on assumptions of strike rate of 10.0 per cent, 8.0 per cent and 6.0 per cent on each of the volatility scenarios. In all, 18 simple European option prices were obtained. A summary of the option prices is presented below :

Table – III

Simple European Option Prices (US $)

Volatility/Strike Rate	*10.0 Per cent*	*8.0 Per cent*	*6.0 Per cent*
Stepup 0.25% points			
12.0 Per cent	82,163	1,22,082	1,69,673
8.0 Per cent	33,095	72,870	1,27,416
4.0 Per cent	8,148	27,370	82,898
Step down 0.25 % points			
12.0 Per cent	23,474	56,191	1,11,868
8.0 Per cent	1,398	12,267	66,668
4.0 Per cent	0	0	20,327

It is evident from the above Table that volatility has a far greater impact on option prices. This may raise doubts about the good fit of the model with respect to pricing swap premiums. This phenomenon could also be explained in the following manner. In the swap tree, since the premiums are based on the up and down movements of interest rates, there is a sort of compensating effect on the premiums. Hence, when volatility changes, the impact becomes compressed. This is not the case in respect of pricing of European call options. Since the payoff in any European call option is max [(St – K), 0], the option will be exercised only when St > K, which implies that only one side of the tree is used to price options.[14]

Section V

Experimenting With Yield Curve Swaps in India

The topic of interest rate risk management has become a matter of growing importance in India for a variety of reasons. First, with the liberalisation of the financial sector, focus on enhancing the value of shareholders' equity is engaging management concern. The focus is not only on increasing profitabilty but also reducing the cost of capital. Secondly, with the deregulation of interest rates in the Indian economy and the increasing integration with the global economy, there would be a tendency for interest rate movements to be more responsive to the evolving situation and predilections can no longer determine the level and structure of interest rates.[15] Finally, there is a growing view that capital needs to be provided for all types of price risk – which includes interest rate risk.

Interest rate deregulation has already made a significant and multifaceted impact on the management and performance of banks and other financial institutions.[16] Investors are more sensitive to interest rate changes now than in the past. Their preference for bonds and stocks are guided by the expectation of capital appreciation rather than the consideration of fixed interest income. Treasury Bills are increasingly becoming price setters for other money market instruments. Domestic interest rates in India are slowly but increasingly integrating with international interest rates, which implies that hedging interest rate risks is fast becoming an integral part of portfolio management of banks and corporates.

As the Reserve Bank Annual Report, 1995-96 points out, "Indian banks have begun to appreciate the critical role of treasury and asset management and the need to improve their skills in these functional areas. The links between money, capital, gilt and foreign exchange markets are getting closer and developments in any one market will have a bearing on other markets. Markets are becoming increasingly sophisticated in that they are constantly in search of information that helps them to work out strategies that minimise risks. Risk management is the key to reducing potential losses and improving assets-liabilities position."

Banks and financial institutions presently hold a large portfolio of Government Stocks of varying maturities and coupons. In the recent years, a new range of instruments including Floating Rate Bonds have been added to Government Stocks. In an environment of deepening and widening of Governemnt Securities market, yield curve swaps seem to offer exciting prospects to banks/financial institutions to manage their cash flows more effectively.

In order to test the validity of the BDT model under Indian conditions, an attempt was made to determine the swap premium using the Indian yield curve and volatility curve. A number of problems were encountered in the process. The first such problem related to the derivation of the zero-coupon yield curve for maturities between 3 months to 2 years. The main instruments in the money market comprise the call money which is limited to banks and Primary Dealers as lenders and borrowers and financial institutions and mutual funds as lenders only, and CDs, CP and T-Bills. The main issue here is to choose one interest rate which will represent the short rates in the market. The interest rate structure on Government Securities is best suited considering the risk neutrality assumption in the pricing of any derivative instrument using binomial trees. The primary yield on T-Bills offered one such alternative but could not be used since it is not effectively market determined. In respect of 364-Day T-Bills, similar restrictions apply. Hence, secondary market yields of T-Bills and Dated Securities were used to construct the following yield curve.

Table – IV

Term Structure of Yields and Volatility : INDIA

Period	*Yield to Maturity*	*Annual Volatility*	*De-Annualized 3-Month Volatility*
3 Month	10.35%	10.50%	N/A
6 Month	10.45%	10.25%	5.13%
9 Month	12.65%	10.00%	7.07%
12 Month	12.84%	9.75%	8.44%
15 Month	13.15%	9.50%	9.50%
18 Month	13.43%	9.25%	10.34%
21 Month	13.48%	9.00%	11.02%
24 Month	13.55%	8.75%	11.58%

In respect of 3-month yield and 1-year yield, the secondary market yields of 91-Day T-Bills and 364-day T-Bills were used, respectively. The balance maturity of 364-Day T-Bills was used to determine the 6-month and 9-month yields. Since no securities with remaining maturity of 15 months were currently being traded, the respective yield was interpolated. Similarly, the 18-month and 24-month yields were approximated using the respective secondary market yields of the coupon securities with balance maturities. Thus, the yield curve constructed above is not a clean zero-coupon bond yield curve (as constructed in the US base case scenario), but built with approximations. Illiquidity in the secondary market and the widening differential between primary cut-off yields and secondary market yields further fragmented the yield curve.

Although coupon rates on T-Bills/GOI Stock have increasingly become market related, historically the cut-off yield on 91-Day T-Bills have not exhibited considerable volatility. In fact, volatility of 91-Day T-Bills primary yields was a mere 1.91 per cent and that of 364-Day T-Bills even lower at 1.15 per cent. No meaningful data base in respect of securities of other maturities traded in the secondary market was available to obtain other volatilities. However, it has been historically observed that, in the Indian case, the yields on 91-day T-Bills have a close relationship with call money rates. The volatility (as measured by the standard deviation) of daily call money rates over the last three years is 10.59 per cent. This has been used as a proxy for the volatility of the three-month yield. A step-down of 25 basis points seemed to be a reasonable approximation for each successive three-month maturity.

The yield and volatility curves depicted in Table IV were fitted using the BDT model. The results are summarised below :

For a notional principal of Rs.10 million, the present value of the swap premium turns out to be Rs.86,971 (0.87 per cent of the principal) for the given yield and volatility curves. In the case of a vanilla swap, the fixed rate payer will have to pay the floating rate payer an annualised 12.90 per cent each quarter. The option prices also seem to be moving in the desired directions. As the strike rate increases, the price of the simple European option is seen to decrease. However, in the absence of a credible yield curve and volatility curve, it is doubtful whether the swap premium reflects the underlying fundamentals.

Concluding Observations

An attempt was made in this paper to fit the BDT model to the Indian yield and volatility curves to determine future short rates and the swap premium under a yield curve swap. This exercise revealed a number of issues relating to the Indian financial markets; *viz.*, the difficulty in construction of a realistic yield curve, and the estimation of volatility. In the absence of authentic data in respect of these two major variables, the pricing of the interest rate swap becomes unrealistic.

While Indian corporates and banks have limited access to derivative instruments like forward rate agreements, options and swaps for their foreign currency exposure, an increasing need is being felt for developing a domestic market for rupee derivatives. The deregulation of interest rates has resulted in increased risk and has heightened the concern for risk cover. With the development of a rupee derivatives market, the range of strategies available for asset-liability management will increase in future. It is here that the absence of a deep and liquid domestic term money market acts as a major impediment to the orderly development of a rupee derivatives market in India. One of the major requirements of a financial derivatives market is a deep and liquid term money market offering a credible and transparent benchmark. This would enable the emergence of a credible rupee yield curve. The interest rate structure would then reflect the service spread between retail deposits and interbank rates; the risk premium of interbank rates over sovereign rates, and the spread between interbank rates and corporate rates. The determination of future short rates will also be more realistic and swap premiums will reflect the underlying fundamentals.

Notes

1. Das S. (1994) Swap and Derivative Financing, p.3.
2. A swap option is a right but not the obligation to enter into a swap, terminate an existing swap, or to extend or shorten an existing swap at some future time at terms that have been agreed to at the outset of the option.
3. John C. Cox, Jonathan E. Ingersoll, Jr., and Stephen Ross, 1985.
4. Rendleman and Bartter assumed that the short-term interest rate behaves like a stock price. One important difference between the interest rates and stock prices is that interest rates appear over time to be pulled back to some long-run average level. This phenomenon is known as mean reversion and is not captured by

the Rendleman and Bartter model.

5. Thomas S.Y. Ho and Sang-Bin-Lee, 1986.
6. Fischer Black, Emanuel Derman, and William Toy, 1991.
7. The Yields as on May 10, 1996 have been used to construct the yield curve. There is no particular significance attached to this date. This was the latest yield curve as on the date of construction of the interest rate tree.
8. It is reemphasised that the volatilities are assumed. In actual practice, historical or implied volatilities can be used to construct the volatility curve.
9. In the original study, the authors have used risk-neutral probabilities of 0.50 for the up and down scenarios. The same is maintained in this study.
10. P(0,2) refers to the price of the security at time period 0 for the period 0 to 2. In this case, it refers to the price at time period 0 for 0 to 6 months. P(1,1,2) refers to the up probability of the price at time period 1 for the period 3 months to six months and P(0,1,2) refers to the down probability of the price at time period 1 for the period 3 months to 6 months.
11. Cox, J, S.Ross and M.Rubinstein, 1979.
12. Volatility for the next period σ (0,4) is defined as the following :

$$\ln((\sqrt[3]{1 \div P(1,1,4) - 1)} \div (\sqrt[3]{1 \div p(0,1,4) - 1))} \div 2 = 8.75 \text{ per cent}$$

and the deannualised volatility is defined as $\sqrt{.75} \times 8.75 = 7.58$ per cent.

13. For the next period, the one-year rates would be : – ln (0.92614656), – ln (0.94091331), and – ln (0.95293793).
14. St is the interest rate at time T and K is the strike rate.
15. S.S.Tarapore, December 1995.
16. Ganti Subrahmanyam, December 1995.

References

Bicksler, J., and A.H. Chen (1986), "An Economic Analysis of Interest Rate Swaps," *The Journal of Finance,* 41, 3, pp. 645-55.

Black, Fischer., Emanuel Derman and William Toy (1990), "A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options," *Financial Analysts Journal,* January - February, pp.33-39.

Chen, Donald, (1989) *New Developments in Commercial Banking,* Ed., Donald Chen, Prentice Hall.

Cox, J.C., J.E. Ingersoll and S.A. Ross (1985), "A Theory of the Term Structure of Interest Rates," *Econometrica,* 53, pp.385-407.

Cox, J.C. S.A. Ross and M. Rubinstein (1979), "Option Pricing : A simplified Approach," *Journal of Financial Economics,* 7, October, pp.229-64.

Das, S. (1999), *Swap and Derivative Financing,* Probus Publishing Company.

Ganti Subrahmanyam (1995). "Approaches to Tracking Interest Rate Movements and Forecasting," Paper Presented at the Bankers Training College, Mumbai, December 18-19.

Ho, Thomas S.Y., and Sang-Bin-Lee (1986), "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance,* 41 December, pp. 1011-29.

Hull, C., (1989) *Options, Futures, and Other Derivative Securities,* Prentice-Hall.

Jamshidian, F. (1980), "An Exact Bond Option Pricing Formula," *Journal of Finance,* 44, March, pp.205-9.

Rendleman, R., and B. Bartter (1980), "The Pricing of Options on Debt Securities," *Journal of Financial and Quantitative Analysis,* 15, March, pp.11-24.

Reserve Bank of India, *Annual Report 1995-96.*

Reserve Bank of India (1995), Report of the Expert Group On Foreign Exchange Markets In India, June.

Smith, C.W. Smithson and L.M. Wakeman (1986), "The Evolving Market For Swaps," *Midland Corporate Finance Journal,* 3, Winter, pp.20-32.

Tarapore, S.S. (1995), "Determining Interest Rates in Deregulated Environment and Techniques of Hedging Interest Rate Risks," Keynote Address at the Bankers Training College, Mumbai, December 18.

Exhibit – I

Short Rates That Match The Yield and Volatility Curves Using the Black, Derman and Toy Model

Date	YTM	Annual Volatility	De-Annualized 3-Month Volatility
8 August 1996	5.11%	8.00%	N.A.
7 November 1996	5.29%	8.25%	4.13%
6 February 1997	5.47%	8.50%	6.01%
8 May 1997	5.64%	8.75%	7.58%
7 August 1997	5.92%	9.00%	9.00%
30 October 1997	6.00%	9.25%	10.34%
1 February 1998	6.10%	9.50%	11.64%
1 May 1998	6.12%	9.75%	12.90%

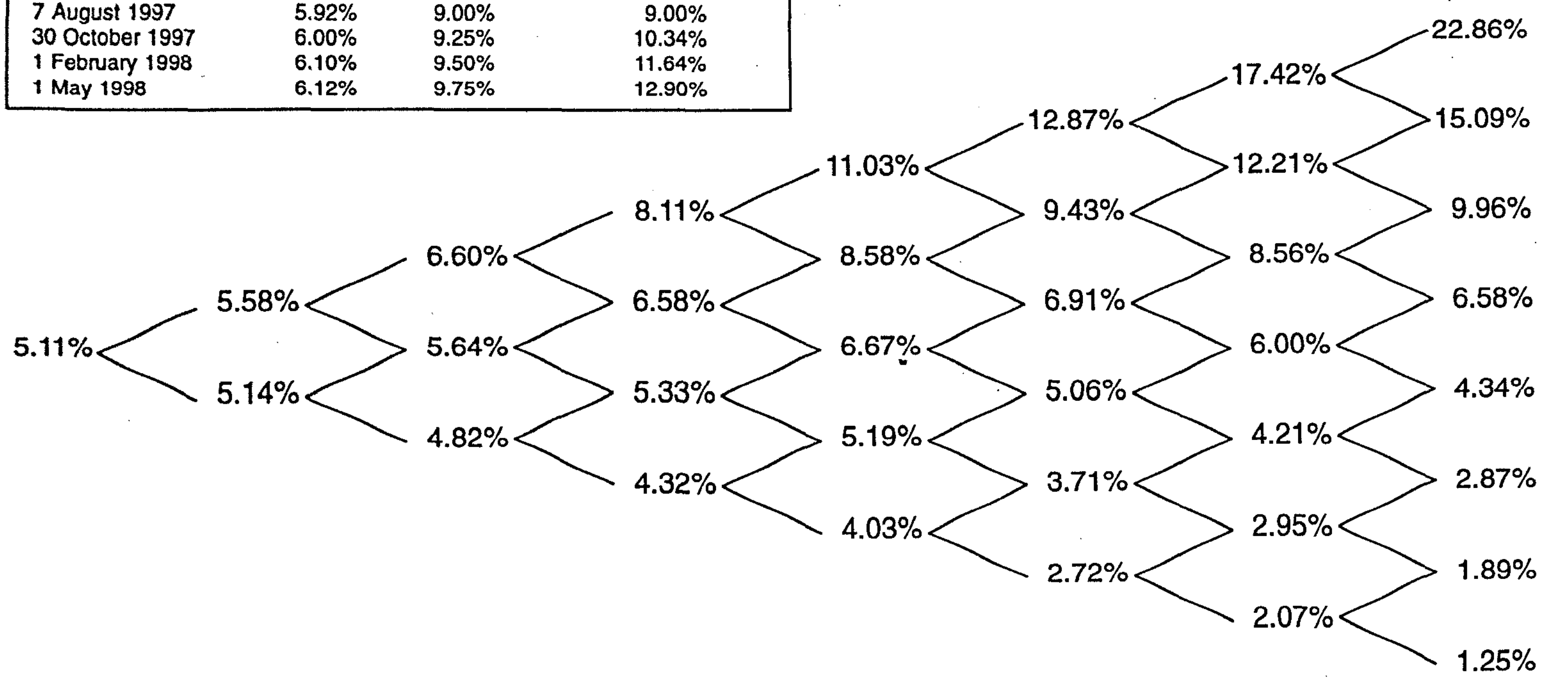
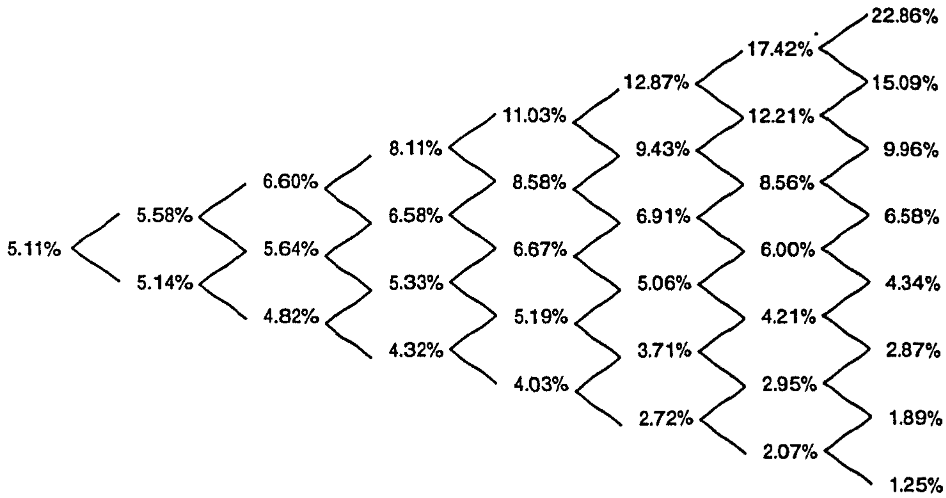


Exhibit – II

21-Month Short Rate Using a 24-Month Zero Coupon Bond – Black, Derman and Toy Model

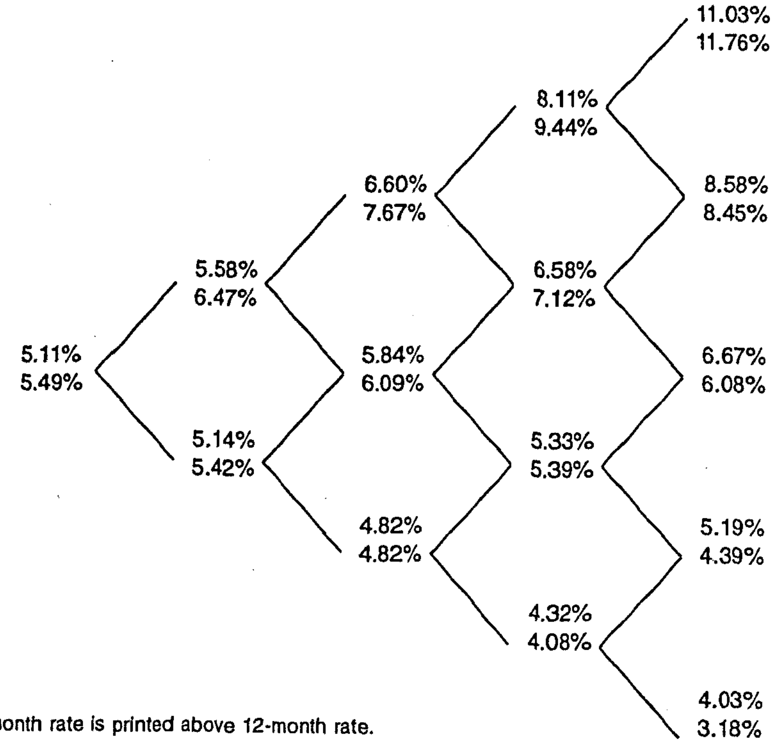


	Up	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Down
Probability	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Rates	5.7145%	3.7729%	2.4910%	1.6448%	1.0858%	0.7169%	0.4733%	0.3125%
Bond Price	0.9459437	0.9636428	0.9756958	0.9838201	0.989285	0.9928822	0.99528926	0.996885
Volatility	12.90%	41.52%	41.52%	41.52%	41.52%	41.52%	41.52%	41.52%
24-Month Bond	6.12%							
Bond Price	0.8879848							
3-Month Bond								
0.987617987								
6-Month Bond								
0.9744555187	0.9862353							
	0.9873115							
9-Month Bond								
0.960844903	0.971297	0.9837752						
	0.9744855	0.9859312						
		0.9880872						
12-Month Bond								
0.946611132	0.955426	0.9660474	0.980132					
	0.9615321	0.9714739	0.9838277					
		0.9763047	0.9868452					
			0.9893057					
15-Month Bond								
0.930631042	0.9373076	0.9454727	0.9566956	0,9731671				
	0.9472896	0.955306	0.9654361	0.97901				
		0.9636215	0.9724396	0.9836021				
			0.9780392	0.9872027				
				0.9800207				
18-Month Bond								
0.916307417	0.9206802	0.9261466	0.9341703	0.9467886	0.9688213			
	0.9349106	0.9409133	0.9486717	0.9594246	0.9769671			
		0.9529379	0.9600079	0.9691078	0.9830221			
			0.9688461	0.9765023	0.9875056			
				0.9821361	0.9908162			
					0.9932556			
21-Month Bond								
0.901567148	0.9032977	0.9056298	0.9098972	0.9179501	0.9342595	0.9582746		
	0.9224429	0.92618	0.9312345	0.9387329	0.9522615	0.9703773		
		0.9424155	0.9475579	0.9543516	0.9654572	0.9790464		
			0.9599975	0.9660264	0.9750665	0.9852171		
				0.9747234	0.982032	0.9895899		
					0.987085	0.9926788		
						0.9948559		
24-Month Bond								
0.88798477	0.8869348	0.8859084	0.886085	0.8890956	0.8990173	0.9149541	0.9459437	
	0.9113005	0.9127188	0.9149533	0.9189976	0.9282036	0.9409451	0.96364282	
		0.9333054	0.9365326	0.9409893	0.9491982	0.9592285	0.97569579	
			0.9525829	0.9570442	0.9641554	0.9719554	0.9838201	
				0.9687163	0.9747457	0.9807352	0.98925854	
					0.9822161	0.9868078	0.99288223	
						0.9909631	0.99528926	
							0.99688486	

Exhibit – III

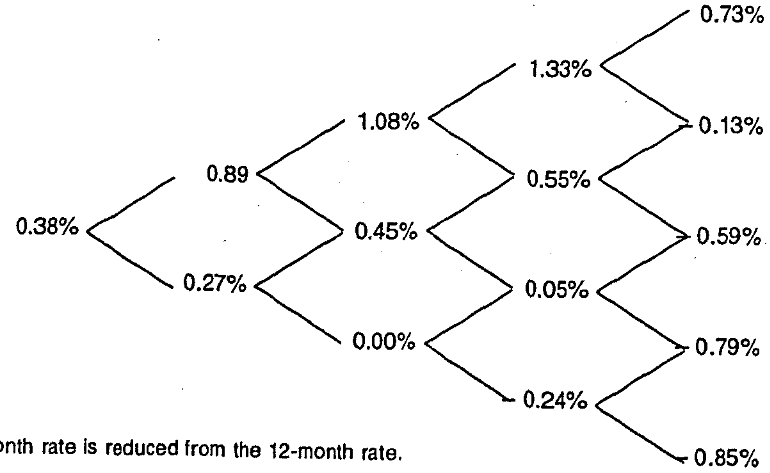
Yield Curve Swap Rate Differential Trees

Annualised 3-Month & 12-Month Swap Rate Tree*



* The 3-month rate is printed above 12-month rate.

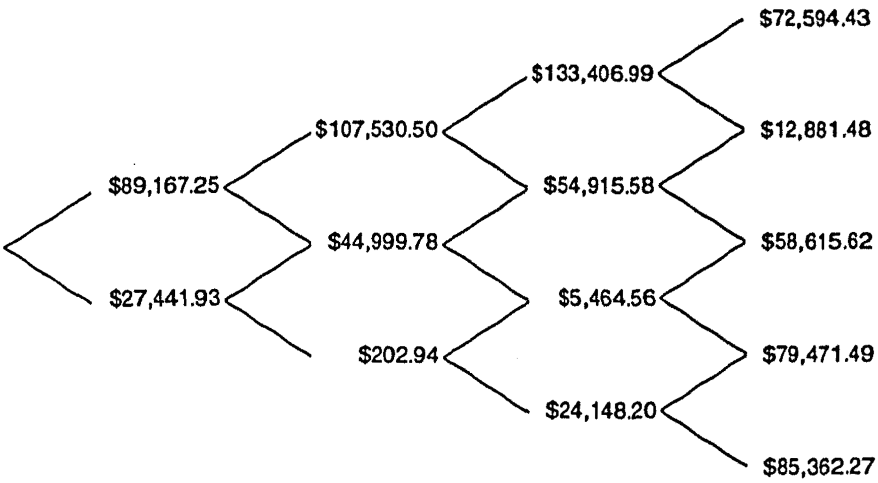
Annualised 3-Month & 12-Month Swap Rate Differential Tree*



* The 3-month rate is reduced from the 12-month rate.

Exhibit – IV
Yield Curve Swap Premium Tree

3-Month and 12-Month Swap Premium Tree



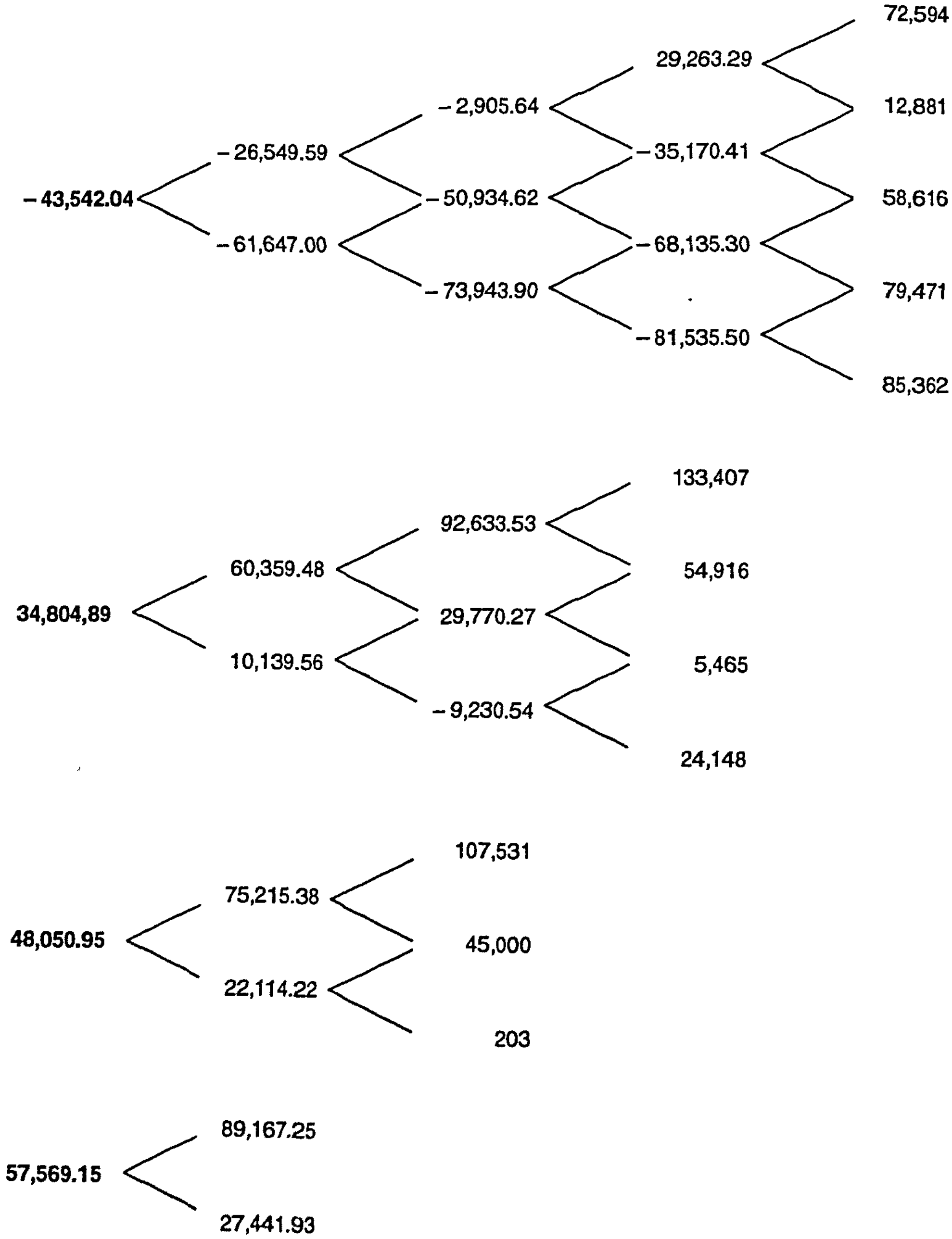
* Assuming a notional principal of $10,000,000

Notional Principal Amount 10,000,000

The amounts that are indicated in the tree above are the premiums that would have to be paid to the 6-month bond holder by the 3-month bond holder.

Exhibit – V

Present Value of Yield Curve Swap Premiums (in us $)



Present Value of the Swap Premium 96,882.94

Reserve Bank of India Occasional Papers
Vol. 17, No. 4, December 1996

NOTE

Structural Changes and Asset-Liability Mismatch of Scheduled Commercial Banks in India

Abhiman Das*

This paper attempts to identify and explore the relationships and structural changes, including hedging behaviour, between assets and liabilities of the cross-section of all scheduled commercial banks in India in two different time points marking the pre- and post-liberalisation phase of banking reforms. Empirical results obtained in this study imply that both public sector and private sector banks showed some systematic changes in the balance sheet proportions during the four years of financial sector reforms beginning with 1991. In respect of asset-liability mismatch, balance sheets of both public and private sector banks are marked with poor matching behaviour in 1991 as well as in 1995 whereas foreign banks showed some significant change in hedging pattern between assets and liabilities in the post-liberalisation period.

Introduction

Beginning with 1991-92, a number of reform measures, *viz.* capital adequacy norms, assets classifications, income recognitions, etc. have been introduced to strengthen the banking sector. Now banks are required to maintain unimpaired capital funds equivalent to the prescribed ratio on the aggregate of the risk weighted assets and also to make 100 per cent provision in respect of loss assets and not less than 30 per cent in respect of sub-standard and doubtful advances. As a consequence, recent years have seen a significant shift in the management of assets and liabilities by banks. Profitability and operational efficiency are given a major emphasis in the ongoing reform process.

---

* Abhiman Das is Research Officer in the Department of Statistical Analysis and Computer Services. He is grateful to Dr. R. B. Burman and Dr. P. C. Sarker for their useful comments on the earlier draft of the paper.

Management of interest margin is emerging as one of the most important means of earning of banks. In this environment, the choice of asset portfolios of banks is expected to be influenced by the kinds of liabilities they hold and vice versa. The composition and term structure of the liabilities and assets have an important bearing on interest rate risks. In view of this, there is a need on the part of the banks to aim at a compatible asset-liability structure. In this milieu, it has been argued that a bank has to identify its asset and liability structure which is not only compatible but also capable of generating net interest revenue that meets its overall earnings objective (Subrahmanyam, 1994). The knowledge of appropriate maturity period and yield to maturity between assets and liabilities would enable banks to envisage and quantify to a reasonable extent their liquidity positions over time. Earlier banks had very limited freedom to trade in securities. For instance, 70 per cent of the trade had to be in the permanent category – that is, the portfolio could not be liquidated, and only 30 per cent in the trading category. But, considering the rise in yield to maturity on approved securities in the recent period and also the need for a rapid transition to a fully marked to market basis of valuation of investments, banks are advised to bifurcate the investments in the ratio of 60:40. In fact, this policy action has given greater flexibility to the banks to correct their asset-liability mismatch and to minimise their exposure to interest rate risks. It is well known that high interest rates and a downward-sloping yield curve can increase the risk exposures for the banks which pursue the traditional method of financial intermediation of "borrow short and lend long". If long term assets are financed by short-term liabilities, banks have to borrow costlier funds from call money market to keep their short-term commitments. On the other hand, if long-term liabilities are used to build up short-term assets, banks have to sacrifice their costlier funds for less remunerative assets. Thus profitability of banks in both the cases could be affected due to adverse interest rate spread. This spread can be optimised by skillful matching of assets and liabilities in the portfolio. The empirical results reported by Stowe *et al.*, (1980) in respect of 510 large US financial corporations reveal several important findings : 1) the firms resorted to hedging for matching the maturity structure of assets and liabilities; 2) commodity-producing firms necessitated higher level of both inventories and accounts payable than service-providing firms; and 3) high-risk businesses rely simultaneously on larger liquidity balances on asset side and less leverage (more equity) on the liability side. A similar study by Simonson *et al.*, (1983) on the cross section of US large and small banks revealed that large banks bear less interest rate risk than the small banks.

In India, there exists a large degree of variation among banks regarding the nature of funds raised and assets acquired, which gives rise to different degrees of interest rate risks. In recent times, following the financial sector reforms, a great deal of attention has been given to the exposure of financial institutions to interest rate risks (Rangarajan, 1994). It has been well recognised by now that the economic agents in India will need to focus on the asset-liability maturity mismatches and the attendant interest rate risks to optimise the return (Tarapore, 1996). In this context there is need to seek empirical evidences regarding the hedging pattern of Indian banks and structural changes in balance sheet proportions, if any, observed in the recent phase of liberalisation.

The purpose of this paper is, therefore, to empirically identify and explore the relationships and structural changes, including hedging (matching) behaviour, between the asset and liability of the cross-section of scheduled commercial banks at two different points of time representing pre- and post-liberalisation periods. Accordingly the data on balance sheet corresponds to 31st March, 1991 and 1995. As we have two sets of variables, instead of regression, the paper uses the canonical correlation technique to investigate the asset-liability relationship of the banks at the two time points.

The rest of the paper is divided into five sections. Section II describes the selection of sample banks, defines the variables used in the analysis and provides some description of the sample banks. Section III briefly outlines the canonical correlation technique employed in this study. Three Sections, IV to VI, are devoted for empirical analysis. Section IV provides the evidence of structural changes of the selected variables in the post reform period. Section V elucidates the structural differences of a particular variable between bank groups at both the time points. Section VI contains the findings of canonical correlation analysis and their interpretation. Section VII concludes with a brief summary.

Section II

Selection of Banks and Definition of Variables

In this study, seventy scheduled commercial banks, which were common to both the time points, i.e. end-March 1991 and end-March 1995, have been considered. These banks have been subdivided into three conventional groups: a) twenty-seven public sector banks including State Bank of India and its subsidiaries, b) twenty-two private sector banks, and c) twenty-one foreign banks. The division of banks into three groups was felt necessary to bring out the structural features among the different bank groups. Generally, public sector banks are large in size compared to private and foreign banks.

The basic idea of the selection of the variables was to take into account the interest sensitivity of the portfolio. Without going into the debate of the time horizon of maturity, the assets and liability are classified as short-term and long-term. In this study demand part of any item on the liability side is considered as short-term and so is the case for assets maturing within one year. It is possible to define several variables on the basis of prior knowledge of maturity period of assets and liabilities. But in absence of adequate information on the maturity break-up in the balance sheet items and keeping in view the basic task on hand, six asset and six liability items, expressed as a proportion of total assets for each of the seventy banks, are taken as variables in the study. The reason of selecting proportions as variables was to eliminate the trend components, if any, and make them comparable across the banks. The liability side variables are defined as follows :

X_1 = Capital i.e., proportion of paid up capital, reserve fund and other resources to the total assets;

X_2 = St.Depo (short-term deposits) i.e., proportion of current deposits and demand part of savings deposits to the total assets;

X_3 = Lt.Depo (long-term deposits) or core deposits i.e., proportion of fixed deposits and time part of savings deposits to the total assets;

X_4 = St.Borr (Short-term borrowings) i.e., proportion of borrowings from banks in India and borrowings from banks outside India to total assets;

X_5 = Lt.Borr (long-term borrowings) i.e., proportion of borrowings from financial institutions from India and abroad to total assets;

X_6 = Oth.Lia (other liabilities) i.e., proportion of bills payable in India and abroad, calls received in advance and miscellaneous liabilities and branch adjustments to total assets;

Assets side variables are defined as follows :

Y_1 = Cash items i.e., proportion of cash in hand, balances with Reserve Bank of India, balances with other banks in current account and money at call and short notice to total assets;

Y_2 = Liq.Secu (liquid securities) i.e., proportion of treasury bills to total assets;

Y_3 = Inv.Secu (investment securities) i.e., proportion of Government securities, approved securities, shares and debentures of companies and corporations, fixed deposits with banks and other investments to total assets;

Y_4 = Lt.Loan (long-term loan) i.e., proportion of term loans to total assets;

Y_5 = St.Loan (short-term loan) i.e., proportion of total loans other than term loans to total assets;

Y_6 = Others i.e., proportion of other assets to total assets;

Section III

Outline of the Technique Employed

Bivariate analysis (such as simple correlation analysis) relates one dependent variable to one independent variable while regression analysis explains a single dependent variable as a function of one or several independent variables. When there are more than one dependent variables and the dependent variables are highly correlated to each other, regression can yield unreliable results as this method ignores the covariance within a set of dependent variables. In that case (as in ours) canonical correlation (which relates a set of independent and a set of dependent variables) may be preferred.

Canonical correlation seeks to identify and quantify the association between two sets of variables. This technique accounts for the covariation of the variables from both within and across sets. The technique was first developed by H. Hotelling (1935, 1936) and was later refined by Cliff, *et al.*, (1976) for application purpose. It may be mentioned that canonical correlations analysis may be regarded as a sort of "double barreled principal component analysis" (Tatsuoka, *et al.*, 1988).

Canonical correlation focuses on the correlation between two sets of linear combination of variables. The idea being to identify the pair of linear combination having the largest correlation. In the next stage the identification process involves choosing the second pair of linear combinations having the second largest correlation among all pairs but uncorrelated with the initial pair. The process continues for the third pair and so on. The pairs of linear combinations are called canonical variables, and their correlations are called canonical correlations. Canonical variables are, in general, artificial, that is, they have no physical meaning (Johnson *et al.*, 1988).

The first group of p variables denoting the liability side is represented by (p x 1) random vector $\underset{\sim}{X}$, and the second group denoting asset side of q variables is represented by (q x 1) random vector $\underset{\sim}{Y}$.

Then the population mean vector and variance-covariance matrices are given by

$$\underset{\sim}{E}(X) = \underset{\sim}{\mu}_x, \text{ and } E(\underset{\sim}{Y}) = \underset{\sim}{\mu}_y$$

$$\text{Var}(\underset{\sim}{X}) = \Sigma_{11}^{pxp} = E(\underset{\sim}{X}-\underset{\sim}{\mu}_x)(\underset{\sim}{X}-\underset{\sim}{\mu}_x)^T$$

$$\text{Var}(\underset{\sim}{Y}) = \Sigma_{22}^{qxq} = E(\underset{\sim}{Y}-\underset{\sim}{\mu}_y)(\underset{\sim}{Y}-\underset{\sim}{\mu}_y)^T$$

$$\text{Cov}(\underset{\sim}{X}, \underset{\sim}{Y}) = \Sigma_{12}^{pxq} = \Sigma_{21}^{qxp}$$

$$= E(\underset{\sim}{X}-\underset{\sim}{\mu}_x)(\underset{\sim}{Y}-\underset{\sim}{\mu}_y)^T$$

The corresponding sample variance-covariance matrices are S_{xx}, S_{yy} and S_{xy} where

$$\bar{\underset{\sim}{x}} = (1/n) \sum_{i=1}^{n} \underset{\sim}{x}_i \text{ and } \bar{\underset{\sim}{y}} = (1/n) \sum_{i=1}^{n} \underset{\sim}{y}_i$$

$$S_{xx} = \{1/(n-1)\} \sum_{i=1}^{n} (\underset{\sim}{x}_i - \bar{\underset{\sim}{x}})(\underset{\sim}{x}_i - \bar{\underset{\sim}{x}})^T$$

$$S_{yy} = \{1/(n-1)\} \sum_{i=1}^{n} (\underset{\sim}{y}_i - \bar{\underset{\sim}{y}})(\underset{\sim}{y}_i - \bar{\underset{\sim}{y}})^T$$

$$S_{xy} = \{1/(n-1)\} \sum_{i=1}^{n} (\underset{\sim}{x}_i - \bar{\underset{\sim}{x}})(\underset{\sim}{y}_i - \bar{\underset{\sim}{y}})^T$$

Let the pairs of linear combinations be denoted by

$$\begin{array}{lllll} u_1 & = \underset{\sim}{a}_1^T \underset{\sim}{x} & & v_1 & = \underset{\sim}{b}_1^T \underset{\sim}{y} \\ & \vdots & & & \vdots \\ u_m & = \underset{\sim}{a}_m^T \underset{\sim}{x} & & v_m & = \underset{\sim}{b}_m^T \underset{\sim}{y} \end{array}$$

Then, u's and v's are called canonical variables; $\underset{\sim}{a}_i$ is a (px1) vector of canonical coefficients and $\underset{\sim}{b}_i$ is a (qx1) vector of canonical coefficients

The first pair of sample canonical variables is obtained in such a way that, $Var(u_1) = Var(v_1) = 1$ and

$$\begin{aligned} Corr(u_1, v_1) &= r_{11} \\ &= (\underset{\sim}{a}_1^T S_{xy} \underset{\sim}{b}_1) / \sqrt{(\underset{\sim}{a}_1^T S_{xx} \underset{\sim}{a}_1)} * \sqrt{(\underset{\sim}{b}_1^T S_{yy} \underset{\sim}{b}_1)} \text{ is maximum} \end{aligned}$$

The canonical coefficients (a_i, b_i) are determined by solving

$$(S_{xy}S_{yy}^{-1} S_{xy}^{T} - \Pi_i S_{xx}) \underset{\sim}{a_i} = \underset{\sim}{0}$$

and

$$(S_{xy}^{T}S_{yy}^{-1} S_{xy} - \Pi_i S_{yy}) \underset{\sim}{b_i} = \underset{\sim}{0}$$

where Π_i's are the ordered eigen values of corresponding characteristic equation.

As the variables are expressed as proportion of total assets, sum of these variables for liability side as well as assets side adds up to 1, which in turn leads to singularity of S_{xx} and S_{yy}. This problem has been avoided by dropping one variable from each side and the results are invariant with respect to which variable is dropped. Interpretation of the relationships between two sides of the balance sheet can be made by examining the correlations, usually termed as canonical loadings, between original variables and canonical variables (Cliff *et al.*, 1976). Statistical tests for canonical correlation and the computation of the loadings of the original variable in the canonical variable were derived by using SAS software (Version 6, 1994).

Section IV

Structural Changes of Variables in the Post Reform Period

In November 1991, Narasimham committee presented its report on financial sector reforms. The report suggested a number of measures to rehabilitate the weak banks, a majority of which were accepted by the Government. Besides, with the globalisation of the Indian economy, banking sector has undergone a perceptible change. As a result, the imperatives of banking have been changing towards the objectives of profitability, efficiency and competitiveness. It is expected that with greater degree of transparency in balance sheet in accordance with competitive environment, the banking sector should witness some significant changes in their balance sheet proportions. While a dramatic change was not possible, a 'slow and solid progress' was expected to take place with the gradual progress of the reform (Tarapore, 1996). This section reviews the progress of banking sector with regard to their balance sheet indicators and presents the major trends observed in recent years.

The association between liability and assets for individual bank groups in 1991 and 1995 is summarised in Tables 1 and 2. In 1991, capital of public sector banks registered highest correlation (0.44) with investment securities, which was replaced by other assets (0.63) in 1995. High positive correlation seen between capital and cash for private and foreign banks in 1991, was not discernible in 1995. For all the bank groups, long-term deposits maintained their positive correlation with long-term loans in both the periods. On the other hand, positive correlation between long-term deposits and long-term investments witnessed in 1991 for public and private sector banks changed to negative correlation in 1995. While short-term deposits and cash, and short-term borrowings and cash were positively correlated in case of public and private sector banks for both the periods, foreign banks registered a high negative correlation (– 0.75) between short-term borrowings and cash items in 1995. In 1991, public sector banks registered highest degree of association (0.85) between short-term deposits and long-term investments which revealed a very high degree of plausible mismatch in the term structure of assets and liabilities. While the problem persisted in 1995, the extent of this relationship is observed to be of lower order (0.45). This trend was also observed for private banks with lower intensity.

To substantiate the evidence of structural change, it is necessary not only to test the equality of the means of variables at two different points of time but also the equality of variation of a particular variable within a bank group at both the time points. Results of respective bank groups are discussed below :

Public Sector Banks :

In 1991, only 2.5 per cent of total assets constituted total capital which significantly increased to 6.1 per cent in 1995. This was due to the introduction of capital adequacy norm of 8 per cent for those banks having branches abroad and 4 per cent for others by end March 1996. Most of the public sector banks have achieved this target. With the help of budget allocation, Government of India had recapitalised to the tune of Rs.10,000 crore during the last four years, of which Rs.3889.21 crore on December 1, 1994 towards additional share capital for 13 public sector banks and in February 1995, an amount of Rs.473.33 crore as additional sum.

There was no significant structural change discernible in deposits (st.depo + lt.depo) as proportion of total assets during this four year period of liberalisation. In 1995, deposits contributed 78 per cent of total assets which was 2 percentage points higher than that in 1991. No significant differences were observed in case of both long-term and short-term deposit structure between the four years period. However, borrowing portfolio (st.borr & lt.borr) of public sector banks showed a significant contraction during this period. The average share of both long-term and short-term borrowings in total liabilities came down between the two time points. On the asset side, there was no visible significant change in respect of cash items. Though the proportion of liquid securities in the bank portfolios doubled during this period, statistically it did not turn out a significant change. Another phenomenon is that the variability of all the variables among banks was significantly higher in 1991 compared to 1995. Investments in Government securities registered a significant increase during this period. The proportion of investment in long-term securities to total assets rose from 29.6 per cent in 1991 to 33.6 per cent in 1995. Besides, the inter-bank variability in proportion of investment in securities to total assets was significantly lower in 1995 than 1991. This suggests that public sector banks revealed some significant changes in their investment pattern. In contrast to this, proportion of long-term loan recorded a significant reduction during this period. It declined from 16.0 per cent to 10.0 per cent during this period. However, short-term loan showed no significant shift at 5 per cent level of significance.

Private Banks

In respect of sources of funds, private banks registered significant changes in two parameters, *viz.* capital and short-term deposits. Proportion of capital in total liabilities more than doubled from 1.7 per cent to 3.5 per cent during this four year period of reform. Short-term deposits declined significantly from 36.5 per cent in 1991 to

31.3 per cent in 1995, although their variability among the private banks remained unaltered during this period. In asset side except cash items, all the parameters showed no significant change during this period. Even the existing variability for most of the variables in 1991 did not differ significantly from that of 1995 even after four years of liberalisation. Thus, private banks in India showed very little change with respect to their balance sheet proportions during the period of reforms.

Foreign Banks

Not a single parameter in the liability side of the balance sheet for foreign banks showed any noticeable (significant) change. Even the capital structure of foreign banks recorded no significant improvement during the past four years of banking sector reforms. Only inter-bank variability in respect of capital and long-term borrowings registered a significant reduction during this period. In asset side, the proportion of cash items declined significantly from 19.9 per cent to 10.8 per cent. The proportion of investments on treasury bills to total assets increased significantly from 1.7 per cent in 1991 to 6.6 per cent in 1995. Inter-bank variability in the foreign bank group for all the items, barring cash items, witnessed no perceptible change.

Section V

Structural Differences between Bank Groups

It is a fact that the manner of functioning of banks has much to do with the objectives they pursue. Given the different objective functions of public and private sector banks in India in the pre-liberalisation period, it was expected that liberalisation process would help to inject competitive elements in the operations of the public sector banks reflecting on their improved balance sheets management. In this section, a comparison between the bank groups is made to draw some significant trends in the balance sheet proportion between the two time points corresponding to pre- and post-liberalisation period.

On an average, public sector banks in 1991 invested 28.7 per cent in interest-sensitive (liquid securities + short-term loan) assets and which was financed by 36.8 per cent of interest-sensitive liabilities (short-term deposits + short-term borrowing). Corresponding ratios were placed at 32.7 per cent and 36.7 per cent in 1995. Thus the gap in the interest sensitive portfolios (difference between interest-sensitive assets and liabilities) declined from – 8.1 per cent in 1991 to – 4.0 per cent in 1995. This gap for private banks was – 6.3 per cent in 1991 and declined remarkably to – 0.3 per cent in 1995. Foreign banks, on the other hand, revealed a completely different picture so far as their interest sensitive portfolio is concerned. Their interest-sensitive assets exceeded interest-sensitive liabilities by as much as +16.1 per cent in 1991 which increased to +19.3 per cent in 1995. It seems that foreign banks preferred risky assets in their portfolio compared to other bank groups which might have been prompted by the motives of earning higher returns. With positive net interest sensitivity, bankers might expect profitable results from rising market interest rates as interest revenues presumably rise faster than interest expenses. Although the public sector banks have reduced the gap in the hedging of interest-sensitive liabilities against such assets in the post-liberalisation period, their position *vis-a-vis* foreign banks shows a remarkable difference even in the post-liberalisation period.

As in earlier section a similar test procedure was conducted for comparison of means between the bank-groups for each time point. The proportion of capital to total assets for public sector banks was significantly higher than private banks in 1991 as well as in 1995. The private sector banks had significantly higher proportion of long-term deposits than public sector banks at both the time points. It may be mentioned that both the bank groups increased their long-term deposits proportion in 1995. However, the increase in proportion of long-term deposits for private banks was much faster than public sector banks. Another noticeable feature was that variability in respect of deposits (short-term and long-term) among banks for both the groups showed no significant difference in 1995. During 1991 to 1995, private banks expanded their short-term borrowing portfolio whereas public sector banks contracted it. The opposite was the case in long-term borrowings. In contrast to differences in liability-structures between public and private sector banks, there was no significant difference in their assets structures, barring cash items.

It is interesting to note that the capital structure of public sector and foreign banks does not differ significantly in 1991 as well as 1995. Even the variability of capital did not differ in 1995 which was significantly different in 1991. Deposit structure of public sector banks and foreign banks were noticeably different in both the periods. The proportion of short-term deposits of public sector banks was more than twice that of foreign banks. The short-term borrowing proportion of foreign banks was significantly higher in 1991. Though there was not much difference in assets structure between public and private sector banks, a significant difference was noticeable between public sector banks and foreign banks especially in case of cash and investment securities. Besides, in 1991, there were differences in case of loan structure also.

Indian private banks had significantly lower proportion of fixed deposits than foreign banks in 1991, whereas in 1995, there was no significant difference in fixed deposits proportion between the bank groups. However, the short-term deposits proportion of foreign banks was significantly lower than private banks in both the time points, short-term borrowing proportion of foreign banks was significantly higher than that of private banks. This shows the extent of emphasis given in foreign banks towards borrowed funds.

Section VI
Asset-Liability Mismatch in Commercial Banks

The simple correlation structure (Tables 1 & 2), which has been studied earlier, reveals how only one variable on asset side is related with another variable on liability side. In canonical correlation structure, this relationship is judged on the basis of loading (correlation) of each variable on the respective canonical variable. The association between two variables belonging to two different sets is interpreted by examining their magnitude of loading on their respective canonical variables. For example, if loading of x_1 on u_1 (first canonical variable on the liability side) is maximum in liability side and y_3 on v_1 (first canonical variable on the asset side) in the asset side, then y_3 is associated with x_1 since the correlation between u_1 and v_1 is maximum provided this correlation is significant. Thus canonical correlation helps to examine which variables on the asset side are associated or related with which variables on the liability side.

The results of separate canonical correlation analysis for three groups of banks in the year 1991 and 1995 are discussed in this section. Five canonical correlations were calculated for each group. As seen from the Table 3, only one of the canonical correlation for all three groups is significant even below 1 per cent level as determined by approximate F likelihood ratio test. It reveals that, in 1991, the inter-relationships between assets and liabilities could be judged based on loading structures of the variables with the first pair of canonical variables (i.e. u_1 & v_1). There were two canonical correlations for public sector banks in 1995 which were significant below 5 per cent level. For private bank group, only the first canonical correlation was significant below 5 per cent level and for foreign bank group, the first two canonical correlations were significant below 10 per cent level (Table 4).

The correlations of the original variables with the canonical variables (the loadings) are given in the Tables 5 to 10. First three tables are related to the year 1991 and the remaining correspond to 1995. In this analysis, the interpretation of the results of the canonical correlation analysis are based on loadings of the variables. Empirical results of public sector banks are analysed first followed by private and foreign banks respectively.

Public Sector Banks

The first canonical variable in 1991 had very large negative loading (– 0.97) for 'other assets' on the asset side and large negative loading (– 0.97) for 'other liabilities' on the liability side (Table 5). The major constituents of 'other liabilities' are bills payable in India & abroad and calls received in advance. In other words, this account represents expected outstanding banks liability. These two accounts *viz.* 'other assets' and 'other liabilities' are influenced simultaneously by major activity in bank acceptances. Acceptances executed and outstanding (bank liabilities) link directly with customers' liability on acceptances outstanding (bank assets). The second highest positive loading (0.96) in asset side was observed for investment securities and the corresponding highest positive loading (0.89) on the liability side was observed for short-term deposits. This suggests that public sector banks with their somewhat high level of short-term funds do tend to emphasize and invest on long-term, non-interest sensitive investment securities. The first canonical variable in 1991 also revealed that a somewhat lower loading (0.71) in cash items on the asset side of public sector banks was associated with the loading (0.84) in long-term (non-interest sensitive) deposits on the liability side. This relationship may look surprising as long-term deposits are not expected to be backed up so much with cash as investments. Since 'cash items' also include the statutory reserve of banks, very little correlation is expected between these two variables. The significant relationship between these two accounts indicates that the long-term liabilities were not adequately covered by the long-term assets by the public sector banks in the pre-liberalisation period.

The first canonical variable for 1995 revealed some different pattern. Highest negative loading (– 0.82) of capital on the liability side was associated with the highest negative loading (– 0.78) of other assets on the asset side. These two accounts moved in the same direction. Second highest loading (0.72) on liability side was observed for short-term (interest-sensitive) borrowing and corresponding second highest loading (0.51) in the asset side was for cash items. This shows that, in 1995, public sector banks moved away from the long-term deposits to short-term funds from the money market to meet their requirements for statutory reserves and cash in hand (Table 8). The second canonical correlation, in 1995, revealed that highest loading (0.77) of investments securities (long-term) on the asset side was associated with the highest loading (0.89) of short-term deposits on the liability side. This relation was also discernible in 1991.

On the whole, public sector banks balance sheets show poor matching behaviour in terms of management of the maturity structure of assets and liabilities and lack of proper hedging activities in the management of risky portfolios. The reform process is yet to make a significant dent on this aspect.

Private Banks

As in the case of public sector banks, the first canonical variable in 1991 for private banks identified the association between 'other liabilities' and 'other assets' (Table 6). The second highest positive loading (0.60) in short-term deposits on the liability side was associated with the loading (0.66) in long-term investment securities on the asset side. Thus with reference to 1991, private banks showed no difference in their balance sheet hedging behaviour in comparison with public sector banks.

In 1995, however, private sector banks showed some different hedging pattern. The first canonical variable revealed that the highest negative loading (-0.69) in capital on the liability side was associated with the highest negative loading (-0.74) in investment securities (long-term) on the asset side (Table 9). This was to be expected as a sizable part of the capital of these banks was invested in Government securities due to the increase in capital base after the introduction of capital adequacy norms. Long-term borrowing of private sector banks was identified with the highest loading (0.85) on the liability side which was associated with the loading in liquid securities (0.52) on the asset side. This implies that private banks more or less show similar portfolio behaviour as public sector banks – borrow long and lend short.

Foreign Banks

As the first canonical correlation in 1991 and first two canonical correlation in 1995 were significant, interpretation is based on the loading of the variables in the first canonical variable in 1991 and first two canonical variables in 1995.

First canonical variable of foreign banks in 1991 had moderately high negative loading (-0.76) for 'other liabilities' on the liability side and corresponding higher negative loading (-0.66) was observed for 'other assets' on the assets side (Table 7). This indicates that these two accounts moved simultaneously in the same direction irrespective of the bank groups. Cash items on the asset side (0.68) and capital (0.47) on the liability side exhibited higher positive loading which implies cash funds were influenced by the capital base in respect of foreign banks. This pattern was, however, not observed in private sector banks. The link between equity and liquidity has been empirically studied by Maisel and Jacobson (1978) who found that banks with poorly hedged balance sheets tend to depend more on equity and if additional liquid cash helps to reduce risk from poorly hedged balance sheets, the equity-liquidity linkage can be a rational response to mismatched assets and liabilities.

In 1995, while the 'other assets' was again seen to be associated with 'other liabilities', long-term deposits of foreign banks were seen to be linked with cash items (Table 10). However, analysis of the loadings in the second canonical variable showed some significant changes in 1995. Highest positive loading (0.51) in long-term deposits on the liability side was associated with the corresponding highest loading (0.82) in long-term investments securities on the asset side. This shows that foreign banks placed their relatively stable funds (relatively less interest sensitive) on long-term investments. This matching behaviour was a special feature of foreign banks alone. Besides, the second canonical variable for foreign banks in 1995 had moderately high negative loading (– 0.74) in short-term borrowings on the liability side and short-term loan (– 0.71) on the asset side. This revealed a distinct balance sheet pattern on the part of foreign banks in matching their assets and liability portfolios in 1995.

Section VII
Summary and Conclusions :

The purpose of the paper was to identify the relationships and structural changes, including hedging pattern, between asset-liability variables of the commercial banks in India by using statistical techniques. The empirical analysis showed that public sector banks and Indian private banks revealed some systematic changes in their portfolio behaviour during the past four years of reform. No significant changes are discernible from foreign banks' balance sheet structure.

The empirical analysis does not support the contention that large size banks in India, because of their greater access to money market sources of funds, show better hedging pattern in their assets and liability management than the small size banks. Public sector banks, which are reasonably large in size, performed relatively poorly in terms of portfolio matching compared to the small size foreign banks.

Foreign banks showed a better hedging ability than the public and private sector banks in the management of interest rate risks in their asset-liability portfolio. Although some marginal changes were noticeable on the portfolio matching behaviour of public sector banks in the post reform period, the reform process is yet to make a significant dent on the interest rate risk management of these banks.

It needs to be noted that the study used only endogenous variables in the analysis of portfolio behaviour. There are a number of external factors which shape the performance of banks. It will therefore be of interest to include appropriate exogenous variables and examine their influences on the structural factors characterising the bank groups.

References

Cliff, N. and D.J.Krus, (1976) "Interpretation of Canonical Analysis: Rotated vs. unrotated solutions", *Psychometrika,* Vol.41, March, pp. 35-42.

Hotelling, H., (1935) "The most Predictable Criterion", *Journal of Educational Psychology,* Vol.26, February, pp. 139-142.

Hotelling, H., (1936) "Relations between two sets of variates", *Biometrika,* Vol.28, December, pp. 139-142.

Johnson, R.A. and D.W. Wichern, (1988) *Applied Multivariate Statistical Analysis,* Second edition, Prentice-Hall International Editions.

Kaiser, H.F., (1958) "An Index of Factorial Simplicity", *Psychometrika,* Vol. 23 September, pp. 187-200.

Maisel, S.T., and R. Jacobson, (1978) "Interest rate changes and commercial bank revenues and costs", *Journal of Financial and Quantitative Analysis,* Vol.13, November, pp. 687-700.

Rangarajan, C., (1994) "Imperatives of Banking in India", *Reserve Bank of India Bulletin,* September, pp. 1059-1064.

Reserve Bank of India; *Annual Report 1994-95.*

SAS Manual, (1994) SAS/STAT, volume 1, version 6, Fourth Edition.

Simonson, D.G., J.D.Stowe and C.J.Watson; (1983) "A Canonical Correlation Analysis of Commercial Banks Asset/Liability Structures", *Journal of Financial and Quantitative Analysis,* Vol.18, No.1, pp. 125-138.

Stowe, J.D., C.J. Watson and T.D. Robertson (1980) "Relationships between the two sides of the balance sheet : A canonical correlation analysis", *Journal of Finance,* Vol.35, September, pp. 973-980.

Subrahmanyam, G., (1994) "Asset-Liability Management for Banks in a deregulated environment", *Prajnan,* April-June, pp. 11-27.

Tarapore, S.S., (1995) "Banking Survey on Reforms", *Business World,* December 13-26, pp. 104-116.

Tarapore, S.S., (1996) "Conduct of Monetary Policy: The Indian Experience", *RBI Newsletter* February 15, Vol.22, No.3.

Tatsuoka, M.M. and P.R. Lohnes, (1988) *Multivariate Analysis : Techniques for Educational and Psychological Research,* Second edition, Macmillan Publishing Company, New York.

Table-1

Correlations Between Asset And Liability Proportions: 1991

a) Public Sector Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	0.0782	0.0375	0.4386	0.1311	0.1883	-0.3387
St.Depo	0.6359	0.2672	0.8494	0.3006	0.4614	-0.8363
Lt.Depo	0.6036	0.2186	0.7843	0.4099	0.3530	-0.8083
St.Borr	0.2739	0.0382	0.2762	0.1832	0.0399	-0.2785
Lt.Borr	0.1758	-0.1226	0.1113	0.1713	0.1130	-0.2143
Others	-0.6946	0.2334	-0.9124	-0.4248	-0.4435	0.9266

b) Private Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	0.4868	0.3544	-0.1574	0.2709	-0.4885	-0.0013
St.Depo	0.4496	0.1782	0.3333	0.1865	-0.0405	-0.5366
Lt.Depo	-0.1479	0.0093	0.4235	-0.0456	0.3475	-0.4520
St.Borr	0.1439	-0.0964	-0.1305	-0.0888	0.2857	-0.1417
Lt.Borr	-0.1106	-0.2000	0.1158	0.0938	0.2507	-0.2762
Others	-0.2731	-0.1149	-0.6004	-0.1273	-0.3369	0.8875

c) Foreign Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	0.7582	-0.0721	-0.3160	-0.4982	-0.1622	0.1524
St.Depo	-0.0802	-0.0135	-0.0736	0.3274	-0.0958	-0.1592
Lt.Depo	-0.2602	0.1533	0.4482	0.1411	0.1083	-0.4249
St.Borr	0.3993	-0.1431	-0.4406	-0.2987	0.1016	0.3082
Lt.Borr	-0.3606	-0.1065	-0.0137	0.0987	-0.0421	0.3861
Others	-0.4649	-0.0369	-0.0857	0.1718	-0.1130	0.4924

Table-2
Correlations Between Asset And Liability Proportions: 1995

a) Public Sector Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	-0.4006	-0.0809	0.4249	-0.4637	0.2070	0.6280
St.Depo	0.0927	0.1156	0.4464	-0.1563	0.1979	-0.3456
Lt.Depo	0.2707	-0.3911	-0.1130	0.0805	0.0798	-0.2400
St.Borr	0.1646	0.2124	-0.4375	0.4764	-0.3661	-0.3458
Lt.Borr	-0.2998	-0.0941	-0.2557	0.2194	0.1046	0.0926
Others	-0.0556	0.3148	-0.4031	0.2343	-0.3578	0.1633

b) Private Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	-0.0912	-0.2236	0.5762	-0.3797	-0.1158	0.2009
St.Depo	0.0198	-0.0199	0.2977	-0.377	0.1654	0.0337
Lt.Depo	0.1302	-0.0574	-0.1827	0.2122	0.1245	-0.3745
St.Borr	-0.3628	0.0050	0.0962	0.0973	-0.3535	0.4244
Lt.Borr	0.0229	0.5459	-0.6447	0.5070	-0.0993	-0.2641
Others	0.1064	-0.0154	-0.1579	0.0478	-0.2381	0.4804

c) Foreign Banks

	Cash	*Liqu.secu*	*Inv.secu*	*St.Loan*	*Lt.Loan*	*Others*
Capital	-0.1490	0.1947	-0.3192	0.3947	-0.1495	-0.2338
St.Depo	0.4178	-0.0518	0.1308	-0.1092	-0.1541	-0.0082
Lt.Depo	0.4362	-0.2035	0.4105	-0.0513	0.0623	-0.5858
St.Borr	-0.7458	0.4733	-0.6351	0.3991	-0.0983	0.2342
Lt.Borr	-0.2317	-0.1265	0.0916	-0.2487	0.0960	0.4613
Others	-0.2214	-0.2515	0.0809	-0.4366	0.1742	0.8405

Table-3

Test of significance for Canonical correlations (1991)

	Canonical Correlation	*Likelihood Ratio*	*Approx. F*	*DF*	*Pr.> F*
Public Sector Banks					
1.	0.9736	0.0323	3.9311	25	0.0001
2.	0.5148	0.6192	0.5906	16	0.8776
3.	0.3520	0.8425	0.3762	9	0.9407
4.	0.1648	0.9616	0.1975	4	0.9382
5.	0.1073	0.9885	0.2445	1	0.6261
Private Banks					
1.	0.9607	0.0218	3.3222	25	0.0002
2.	0.7598	0.2824	1.2929	16	0.2482
3.	0.5284	0.6680	0.6856	9	0.7166
4.	0.2472	0.9268	0.2905	4	0.8818
5.	0.1135	0.9871	0.2089	1	0.6537
Foreign Banks					
1.	0.9074	0.0412	2.3032	25	0.0081
2.	0.7970	0.2334	1.4222	16	0.1842
3.	0.5200	0.6398	0.7115	9	0.6942
4.	0.3444	0.8769	0.4751	4	0.7536
5.	0.0714	0.9949	0.0769	1	0.7854

Table-4

Test of significance for Canonical Correlations (1995)

	Canonical Correlation	*Likelihood Ratio*	*Approx. F*	*DF*	*Pr.> F*
Public Sector Banks					
1.	0.8136	0.0884	2.3822	25	0.0028
2.	0.7330	0.2616	1.9159	16	0.0382
3.	0.5841	0.5654	1.3610	9	0.2332
4.	0.3635	0.8581	0.7949	4	0.5355
5.	0.1059	0.9888	0.2383	1	0.6305
Private Banks					
1.	0.9131	0.0611	2.0692	25	0.0160
2.	0.7022	0.3674	0.9782	16	0.4967
3.	0.4553	0.7248	0.5376	9	0.8368
4.	0.2493	0.9144	0.3431	4	0.8467
5.	0.1580	0.9750	0.4098	1	0.5311
Foreign Banks					
1.	0.8969	0.0333	2.5405	25	0.0036
2.	0.7717	0.1703	1.8302	16	0.0641
3.	0.6568	0.4209	1.5082	9	0.1876
4.	0.5055	0.7402	1.1361	4	0.3598
5.	0.0757	0.9943	0.0863	1	0.7729

Table-5

Correlations of original varables with canonical variables for Public Sector Banks in 1991

Variables	*Loadings* Canonical Variables 1	2	3	4
Liabilities				
X_1 Capital	0.4092	0.4503	-0.0457	-0.0186
X_2 St.Depo	0.8932	-0.1144	0.1895	-0.3035
X_3 Lt.Depo	0.8388	0.0421	-0.1569	0.3028
X_4 St.Borr	0.2949	-0.0792	-0.0360	-0.2283
X_5 Lt.Borr	0.1288	-0.1452	0.4445	0.6483
X_6 Oth.Lia	-0.9651	0.0207	-0.0387	-0.1056
Assets				
Y_1 Cash	0.7146	-0.5908	-0.1159	0.0938
Y_2 Liq Secu	0.2756	-0.2261	-0.3375	-0.1634
Y_3 Inv Secu	0.9554	0.1080	0.0423	-0.0379
Y_4 St.Loan	0.4067	0.1505	0.0868	0.2068
Y_5 Lt.Loan	0.4895	-0.2146	0.1573	0.1461
Y_6 Others	-0.9684	0.1171	-0.0938	-0.1693

Table-6

Correlations of original variables with canonical variables for Private Banks in 1991

Variables	*Loadings* Canonical Variables 1	2	3	4
Liabilities				
X_1 Capital	0.0649	0.7943	-0.1525	0.4996
X_2 St.Depo	0.6045	0.4153	0.0964	-0.1111
X_3 Lt.Depo	0.5240	-0.3970	-0.1804	-0.1411
X_4 St.Borr	0.0053	-0.1298	0.7713	-0.1400
X_5 Lt.Borr	0.1948	-0.5575	0.1951	0.7519
X_6 Oth.Lia	-0.9607	0.0894	-0.1167	0.0445
Assets				
Y_1 Cash	0.3193	0.7185	0.4980	0.3318
Y_2 Liq Secu	0.1565	0.5013	-0.2168	-0.0071
Y_3 Inv Secu	0.6597	-0.2661	-0.2805	-0.2830
Y_4 St.Loan	0.1815	0.2156	-0.0321	0.6250
Y_5 Lt.Loan	0.2671	-0.6067	0.3591	-0.4573
Y_6 Others	-0.9338	0.0825	-0.2830	-0.1149

Table-7

Correlations of original variables with canonical variables for Foreign Banks in 1991

Variables	*Loadings*			
	Canonical Variables			
	1	*2*	*3*	*4*
Liabilities				
X_1 Capital	0.4664	-0.7457	0.4233	-0.0466
X_2 St.Depo	-0.0134	0.0685	-0.0248	0.6061
X_3 Lt.Depo	0.2259	0.7655	-0.1990	-0.4706
X_4 St.Borr	-0.0024	-0.8925	-0.1605	0.3105
X_5 Lt.Borr	-0.6316	0.0567	0.4889	0.5886
X_6 Oth.Lia	-0.7639	-0.0058	-0.0898	-0.4460
Assets				
Y_1 Cash	0.6818	-0.6323	0.3143	-0.1501
Y_2 Liq Secu	0.1125	0.1620	-0.0604	-0.0927
Y_3 Inv Secu	0.0680	0.6341	0.0267	-0.0958
Y_4 St.Loan	-0.1826	0.4780	-0.2973	0.3461
Y_5 Lt.Loan	-0.0288	0.0552	-0.5606	0.3969
Y_6 Others	-0.6588	-0.5388	0.3531	-0.3511

Table-8

Correlation of original variables with cononical variables for Public Sector Banks in 1995

Variables	*Loadings*			
	Canonical Variables			
	1	*2*	*3*	*4*
Liabilities				
X_1 Capital	-0.8175	0.1318	0.3755	0.1712
X_2 St.Depo	0.2908	0.8876	0.2678	-0.1019
X_3 Lt.Depo	-0.0096	-0.0592	-0.9248	0.2758
X_4 St.Borr	0.7249	-0.3345	0.1855	-0.2755
X_5 Lt.Borr	-0.1739	-0.2555	-0.1204	-0.6583
X_6 Oth.Lia	0.2159	-0.6594	0.4639	-0.1039
Assets				
Y_1 Cash	0.5492	0.1049	-0.3808	0.4971
Y_2 Liq Secu	0.2615	-0.0284	0.5245	-0.2480
Y_3 Inv Secu	-0.3628	0.7740	0.2563	0.4372
Y_4 St.Loan	0.5082	-0.4407	-0.1659	-0.3785
Y_5 Lt.Loan	-0.4117	0.5202	-0.3243	-0.4923
Y_6 Others	-0.7822	-0.3529	0.4830	0.1539

Table-9
Correlations of original variables with carronical variables for Private Banks in 1995

Variables	Loadings			
	Canonical Variables			
	1	*2*	*3*	*4*
Liabilities				
X_1 Capital	-0.6891	0.3183	0.2044	0.1900
X_2 St.Depo	-0.2396	0.5696	0.3831	0.2936
X_3 Lt.Depo	0.3908	-0.2207	-0.7625	-0.1271
X_4 St.Borr	-0.4110	-0.5214	0.2945	0.1061
X_5 Lt.Borr	0.8462	-0.1717	0.2408	0.1137
X_6 Oth.Lia	-0.2227	-0.0926	0.5919	-0.6562
Assets				
Y_1 Cash	0.2098	0.5028	-0.1937	-0.7725
Y_2 Liq Secu	0.5212	-0.0883	0.6232	0.2878
Y_3 Inv Secu	-0.7433	0.3609	-0.3651	0.4118
Y_4 St.Loan	0.4837	-0.4871	0.2450	-0.1860
Y_5 Lt.Loan	-0.1119	0.3197	-0.5717	0.2272
Y_6 Others	-0.4734	-0.4126	0.6155	-0.3283

Table-10
Correlations of original variables with canonical variables for Foreign Banks in 1995

Variables	Loadings			
	Canonical Variables			
	1	*2*	*3*	*4*
Liabilities				
X_1 Capital	0.1864	-0.4395	0.1144	0.0858
X_2 St.Depo	0.1777	-0.0400	0.2688	0.9385
X_3 Lt.Depo	0.7110	0.5114	-0.0871	-0.3783
X_4 St.Borr	-0.5166	-0.7424	0.0972	-0.3996
X_5 Lt.Borr	-0.6449	0.4509	0.3052	-0.2795
X_6 Oth.Lia	-0.8699	0.2204	-0.2786	0.1328
Assets				
Y_1 Cash	0.4929	0.5933	-0.0267	0.5926
Y_2 Liq Secu	0.0394	-0.6454	0.4934	-0.2638
Y_3 Inv Secu	0.1595	0.8181	-0.0685	0.2489
Y_4 St.Loan	0.2561	-0.7114	0.2153	-0.3658
Y_5 Lt.Loan	-0.0923	0.2613	-0.4145	-0.0938
Y_6 Others	-0.8851	0.1547	-0.2840	0.3219

Reserve Bank of India Occasional Papers
Vol. 17, No. 4, December 1996

BOOK REVIEWS

International Debt Reexamined, William R. Cline, Institute For International Economics, Washington, D. C, February 1995, pp. xv + 535

There has been a stimulating interest in the literature in recent years on the international debt crisis, first signalled by the Mexican debt repudiation of 1982. This study by Cline – undoubtedly the most comprehensive on the subject till date – tries to make sense of this "historic financial episode" and to derive policy lessons for the future. The study judges the overall international debt strategy as successful in that it avoided a systemic collapse and restored capital market access to debtor countries within a span of a decade.

A lesson to be learnt from the experience is that contingent policy strategy supported by continuous analytical insights into the fundamental changes in the world economy based on evolving experience and new information, can contribute to systemic stability. The book identifies domestic fiscal balance as the single most important policy requirement for minimising the risk of external debt problems. This is not to undermine the importance of the current account deficit, which the study warns, should be kept at levels consistent with medium-term sustainability. While Cline is critical of the US policy mix of tight monetary and loose fiscal policy in the early 1980s, which in his view, prolonged the debt crisis, he advocates an open outward-oriented economy, a realistic exchange rate and structural reforms in the trade and industrial sectors as the basic elements of a strategy to a successful management of international debt. In this, he is guided by the Latin American experience where domestic policy reforms played an important part in resolving the debt crisis.

Chapter 2 examines the principal economic indicators for debt and growth of developing countries. The empirical review on the debt burden data in this chapter along with the capital inflows data reviewed in Chapter 8 leads the author to suggest that at least for the Latin American countries, the debt crisis was overcome by 1992. The study affirms that for the 17 Heavily Indebted Countries, it was the brisk recovery of export earnings combined with a build up of reserves that fully offset any rise in debt, rather than a massive write-down of debt, that caused an improvement in debt indicators in the period 1989-93 (p.45). In the author's view, rather than generating trade deficits, the sub-Saharan African countries should run trade surpluses so that they could pay much of the interest on past debt. This, however, is a standard IMF prescription for improving the creditworthiness of debt-ridden countries, although it involves stifling imports even at the cost of growth. The study points out that by 1990, five other countries had joined the ranks of superdebtors : India, Indonesia, Egypt, Turkey and Poland. However, the rise of debt in these countries reflected primarily official rather than private lending. The study observes that the rising trend in debt for India and Pakistan "may be interpreted as a reflection of increased integration into world capital markets and access to official credit" (p.68). Although the experience of sub-Saharan countries is characterised as different from that of the Latin American countries, the study advocates the same prescription.

The book provides a "connoisseur's tour," on the literature that emerged on the issues in international debt. A thematic rather than a chronological presentation of the theoretical literature in debt provides a coherent exposition of the complex issues in this area. The book reviews the various perspectives on the incentives to default. One perspective is that borrowers are inherently dishonest and will default if it is to their benefit. At the other end of the spectrum is the view that debtor countries have an interest in honouring their debt because of the stake in future market access. The experience of the international debt crisis suggests that the latter view has more acceptability than the former. Although external debt had reached unsustainable levels by the beginning of the `eighties, there was no generalised repudiation of debt or of debt servicing, characterising the debtors' perceptions regarding the negative externalities in default. This section also highlights the important element of "honour" of national pride in the commitment to international rules of the game on the part of many debtor country governments. Cline illustrates this concept using the behaviour of Chile, Colombia, South Korea and Indonesia (a glaring omission being the Indian experience of 1991-92).

As the debt crisis prolonged into the late 1980s, analysts shifted their focus from the "external transfer problem" to "internal transfer problem." This strand of literature emphasised that unsustainable fiscal deficits were largely instrumental in increasing external debt of the developing countries. Authors who advocated the internal debt problem did not see debt forgiveness as the solution to the fiscal constraint; instead they focussed on domestic fiscal reform as the centrepiece of the strategy to relieve the debt burden. On the other hand, Krugman and others, the proponents of the debt overhang hypothesis, argued that the distortions created by the presence of a debt overhang could be minimised if creditors provided immediate debt forgiveness. To use Krugman's terminology, since the debt was so high that countries were on the wrong side of the 'debt relief Laffer curve', partial forgiveness could provide stimulus to growth and adjustment, and bring about the reversal of capital flight.

In Chapter 5, Cline evaluates the performance of the international debt strategy which, he argues, was brilliantly successful in preserving international financial stability and restoring the debtors' access to credit markets, but failed to stimulate economic growth.

Initially, the debt problem was viewed as one of illiquidity rather than insolvency. The main thrust of this early analysis (of which Cline was a major proponent) was that with recovery from the global recession, it should be possible for major countries to overcome payments problems and gradually return to creditworthiness. Based on the premise of illiquidity, debt reschedulings accompanied by IMF adjustment programmes were regarded as capable of bailing out the indebted countries. Debt reschedulings, however, were limited to principal repayments and not to interest payments. IMF programmes could not be made effective within a reasonable time owing to the inability to attain the "critical mass" in terms of new money needed to bridge the financing gaps.

As debt reschedulings often proved difficult, the Baker Plan sought to address the debt problem with focus on adjustment in debtor countries, backed by 'new money' from commercial banks and international financial institutions. However, there were several impediments to the new concerted lending that the Baker Plan had envisaged. Over time, the needs of creditor banks became highly differentiated. Commercial banks reduced their exposures to the Baker identified countries as they strengthened their balance sheets and increased their loan loss reserves. Differences in tax and accounting regulations, disclosure norms and prudential norms also contributed to fragmentation of creditors. Further, free riders lowered the incentives for creditors to provide new money.

The market-based menu approach was in many ways a natural evolution of the debt strategy as the tensions inherent within the concerted approach became manifest. The development of a secondary market for bank claims had both positive and negative effects on banks' attitudes. Although banks benefited from the opportunity to adjust their portfolios, the base for new concerted lending eroded as banks used the market to retire debt. There was a widespread agreement that an efficient solution to the debt problem required both debt reduction and economic growth.

The Brady Plan was a tacit acceptance of the debt overhang proposition, with the IMF and the World Bank agreeing to set aside funds for debt and debt-service reduction. Backed by data for 18 Brady deals, Cline concludes that "for all practical purposes the Brady Plan has been all forgiveness and no new money." The asymmetrical allocation, according to Cline, was accomplished either by debtor suasion (Mexico), outright preclusion of new money by the country negotiators (Argentina) or restrictive limits (Brazil).

With the lessons of the experience of international debt policy, the study recommends a three-fold agenda for future policy : prevent a repeat of the 1980s debt crisis; encourage sustainable capital inflows into productive investment in developing countries; and reinforce sound domestic economic policies and discourage weak ones.

Chapters 6 and 7 review the specific debt problems of different country groups. Reviewing the experience of adjustment to the debt crisis in the seven largest Latin American countries, the author places emphasis on fiscal adjustment as the single most important factor in achieving domestic stabilisation and resolution of the debt problem. On the same lines, he suggests that the extent of indebtedness in

Russia is not so severe as to indicate a need for significant forgiveness; instead the problem is domestic macroeconomic chaos. This Chapter also develops debt simulations for the 45 sub-Saharan African countries.

Statistical tests carried out by the author suggest that the bond market has been discriminating rather than promiscuous in its upsurge in the 1990s. After examining whether there is likely to be a new debt crisis in the next decade or so, the book suggests that the extent of borrowing today is "much less troublesome" than it was during the last two decades. The book concludes with yet another suggestion on institutional changes in the international credit market. Cline puts forth a proposal to create an International Bondholders' Insurance Corporation under the aegis of the World Bank, whose purpose would be to provide insurance of international bonds issued by developing countries, in return for premiums paid by bond purchasers (p.482). Cline's random-shock experiments to investigate the costs and profitability of the proposed new institution no doubt indicate that such an entity might on average earn significant profits, but the attendant risks could be large as well. Also noble is Cline's intentions when he suggests that half of the proposed capital of $300 million could be raised through issue of stock to the private sector and the remaining half from the official sector. But one needs to remember that nearly all the proposals relating to setting up of similar institutions, that were made during the 1980s, were shot down on the issue of raising capital.

This outstanding study by Cline is a must for all researchers in the field of international finance. Under one cover, the reader gets what is perhaps the most comprehensive and accurate coverage of the debt crisis and its aftermath. As Paul Volcker, former Chairman, Federal Reserve Board, has commented, "this book will be the definitive work on the debt crisis."

A. Prasad*

* Dr. A. Prasad is Assistant Adviser in the Department of Economic Analysis and Policy and is presently attached to the Secretary's Department.

Reserve Bank of India Occasional Papers
Vol. 17, No. 4, December 1996

***Is The Economic Cycle Still Alive? Theory, Evidence and Policies* – (Eds) Mario Baldassarri and Paolo Annunziato, St. Martin's Press, 1994, pp. 303, Price £ 47.50**

This book outlines issues and developments in the business cycle literature of the present century. The book contains ten excellent contributions from well known experts besides a competent introduction by the editors capturing the essence of various arguments presented in the volume. Although the subject of business cycle is as old as the history of economic discipline itself, as noted by the editors, interest in the business cycle phenomenon, however, has had a cycle of its own – high during periods of considerable economic instability and significantly low in the periods of continuous growth. It may be noted that in periods of sustained prosperity, for example in the 1960s, the policy makers were fine tunning their economies in accordance with the demand management principle suggested by Keynes. Towards the end of 1960s, the existence of business cycles was in doubt and in certain quarters, even questioned. However, the experience of stagnation and macro economic instability in the industrialised countries from about the middle of 1970s and early 1980s brought about a resurgence of interest in the business cycle literature.

The book has set in motion a number of debating points in so far as it points out that business cycle is a product of the failure of old solutions. This has been the main reason why over the years the literature on the causes of economic fluctuations and their measurement has shown a remarkable growth. The business cycle analysis, as the book perceives, almost coincides with short-term macro-economic analysis and has many common points with the economics of growth, money, inflation, technical change and expectations.

In the last two decades, there has been a phenomenal growth of the empirical literature relating to business cycle phenomena. Infact, it is the interest in the business cycle which has led to many refinements in econometric practices, particularly in time series analysis. The most fundamental issue in the business cycle literature relates to the nature of macro-economic time series. Until the end of the 1970s it was usual in macro-econometric studies to split aggregate series into a non-stationary components, a so-called trend component and a stationary residual, identified with the cyclical component. The traditional approach of decomposition of an economic time series into trend and cycle components was considered consistent with economic theory at a time when growth and cycles were viewed as independent of each other. Perceptions, however, changed with the advent of newer econometric techniques which revolutionised the concept of integrated time series with the focus on the long term behaviour of economic variables. In particular, it was observed that most of the time series were non-stationary and could be modelled with a stochastic trend rather than a deterministic trend that was postulated by the traditional economic theory. Further, a shock to an integrated process will persist forever rather than fade away as in the case of a non-integrated series. In this volume, Micro Lippi explains that it would be erroneous to model an economic time series as trend stationary if it were actually an integrated process (or difference stationary process) and *vice versa.* He rightly emphasises that the variability of trend itself is dependent on the functional form.

It is well known that the renewed interest in business cycle theory originated from the crisis of Keynesian macro-economics in the 1970s and 1980s. The rethinking was inspired by the absence of solid micro-economic foundation in aggregative models. In other words, it was not clear how aggregate relations were derived from precise rules of individual behaviour. While this shortcoming in the Keynesian model brought to focus the neo-classical models based on individual choice much of what constitutes the business cycle theory emerged as a fusion of neo-classical inter-temporal models with Walrasian equilibrium analysis. Starting from the original asymmetric information model or Monetary Business Cycle model developed by Lucas and Barro in early 1970s, equilibrium business cycle has gradually evolved into Real Business Cycle model pioneered by Kydland and Prescott and subsequently furthered by King and Plosser, Nelson and others. In this volume, Gschiltzer provides a critical review of this course of theoretical development in the business cycle literature.

There are two papers in the volume, authored by Paolo Annunziato and Ronny Nilsson on the use of cyclical indicators. Paolo

Annunziato provides a comprehensive survey of literature on the origin and evolution of cyclical indicators, theoretical and measurement problems in the construction of these indicators and the uses of cyclical indicators for forecasting business cycle fluctuations. Ronny Nilsson provides an excellent exposition of the various procedures and steps required for the identification of the cyclical indicators, the phases of business cycle and the construction of a composite indicator to predict the turning points of cycles, taking the OECD countries as reference point. These two papers have also surveyed the major economic indicators which are regularly studied by the U.S. Department of Commerce and OECD countries. These two papers are of particular interest to Indian researchers interested in the evolution and development of leading indicators.

The cyclical indicators approach to analysing the business cycle fluctuations and forecasting macro-economic time series owes its origin to A.F. Burns and W. Mitchell of the National Bureau of Economic Research of the U.S. way back in 1937. Since then this literature has survived inspite of Koopman's sharp criticism that this is a "measurement without theory". The most important factor for the survival of this literature, as emphasised by Moore in this volume, is the low degree of precision associated with many of the macro-economic models, or in the words of Wecker, "my model predicts well most of the time but misses at the turning points". In fact, the poor forecasting performance of standard econometric model has been a major reason why the cyclical indicator approach has acquired popularity in many industrialised countries for short term forecasting of levels of economic activity.

Economic indicators can be classified into five broad categories such as reference indicator, leading indicators, lagging indicators, coincident indicator, and composite (synthetic) indicator. Economic indicators can also be classified as early stage indicators, rapidly responsive indicators, prime movers, and market sensitive indicators. The reference indicator is the economic variable whose cyclical movement is to be predicted. Usually, real variables *viz.*, output, index of industrial production (IIP), *per capita* GNP, level of employment or level of capital stock are considered as reference indicators. In fact, the choice of the reference indicator has generated a great deal of theoretical and empirical debate among economists initiated mainly by Milton Friedman and A. Schwartz and carried forward by Lucas and Barro. According to Friedman and Schwartz, movement in monetary variables such as money stock could be used as reference indicator for fluctuation in economic activities. From the empirical point of view, it however needs to be analysed whether the chosen indicators have the ability to predict fluctuations in the final outcomes that one seeks at. This is akin to what two pioneers in this field, Stock and Watson, have put it as "what should the leading indicators" lead?

Once a reference indicator is chosen, other kinds of indicators can be identified. If the cyclical movements of an economic indicator precede those of the reference indicator, then it could be called a leading indicator. If the movements of an indicator follow the reference indicator, then it can be regarded as a lagging indicator. On the other hand, coincident indicators are those whose movements are similar to the reference indicator. A composite indicator synthesizes the information contained in the component indicators and is thus, a weighted average of these component indicators. However, it is not clear in the cyclical indicators approach what normative and positive criterion should be considered while giving weights to different indicators in order to construct a synthetic indicator? In this volume, Ronny Nilsson has asserted that theoretical insights, statistical regularity, and availability of data on relevant indicators could be some of the useful criteria for choosing the indicators. The discussion on cyclical indicators in the book is enriched by P. Annunziato's reflections on some of the statistical problems and techniques relating to indicators.

After giving a theoretical outline of the issues relating to economic cycle, the book quickly moves over to the empirical issues particularly the decomposition of innovations into demand and supply shocks. While Paolo Onofri, Paolo Paruolo and Bruno Salituro have explored in considerable detail as to how to interpret technical progress from the viewpoint of its importance for economic cycles, Stefano Fachin, Andrea Gavosto and Guido Pellegrini demonstrate the importance of supply shocks in causing fluctuations in industrial production in Italy, France and Germany and to a lesser extent in the United Kingdom.

The final section of the volume deals with the life history of business cycle. An interesting question posed by the book is: "Did business cycle exist in the real world economy". Innocenzo Cipoletta addresses this question by giving the physician interpretation of real economy which was advanced by a French doctor in economic science, named, Clement Juglar, long ago in the mid-nineteenth century. Juglar interpreted that an economic system, like a human body, follows a cycle of birth, development, adulthood and decay. As in the case of human body, an illness should be studied not when its symptoms manifest but much before that, when the economy appeared healthy, as Juglar would contend. But Juglar's prescription in this regard does not conform to the conventional patient's behaviour namely that unless and until one is affected by a disease, no one would go to a doctor.

Cipoletta points out that there have been three principal arguments to justify the contention that business cycle is long dead in real world economy. These are the existence of built-in stabilisers, the increased importance of the services sector, and changes in the production processes. These mechanisms are believed to have attenuated the effects of cyclical fluctuations, their size, form and duration and helped the more minor fluctuations to disappear. Cipoletta argues that although cyclical fluctuations have lost their "irregular regularity" in the way Schumpeter referred to them, the present day economists are not so much interested in the form of the cycle as economies have capability to produce short term variations in activity. It is here that increasingly complex statistical techniques have been applied to identify regular cyclical variations in economic activities. It is precisely to the attempt at identifying a regular cycle that helped realise a most promising work of real business cycle theory in the early 1980s. The real business cycle approach has the advantage of emphasising strong inter-relationships between the cycle and the trend, that is, between the short-term economic cycle and the structural changes in economic activity. As succinctly put by Cipoletta, "if most of the short-term movements can be ascribed to the tendency which changes due to the transitory phenomena and which can affect tendential behaviour through hysteresis, then it is difficult and perhaps unproductive to separate the business cycle from the trend".

An important lesson in the book is that short term corrective measures and structural policies must be undertaken in a co-ordinated fashion to minimise the volatility of economic activity. In other words, there can be no two-stage policy; short term measures need to be woven into the more substantial long term structural measures to move the economy along a sustainable long run growth path. Highlighting the importance of policy co-ordination, Cipoletta shows how excessive focus on short-run monetary policy in the Italian economy produced rigidities in the economic system and stifled the growth process in Italy. The short-term use of monetary policy in the last fifteen years to reduce inflation has lead to a permanent rise in interest rates which in the absence of supportive fiscal and structural policy actions, had adverse repercussions on the credit and debt situation in the Italian economy.

To sum up, the book demonstrates that as trend is a variable and as trends and cycles are inseparably linked, cycles are bound to prevail. Any policy intervention to fine-tune cycle, must also address the trend itself, that is, the success of economic policies depends not on short-term measures alone to remove the temporary drift from the trend but on how the short-run and long-run measures combine to remove cyclical fluctuations in economic activities with a view to ensuring long-run growth in the economy. The book is enriched with wealth of theoretical and empirical insights and would be widely read by those who are interested in the business cycle literature and short-term economic analysis.

S.C. Dhal*

* S.C. Dhal is Research Officer in the Department of Economic Analysis and Policy.

Reserve Bank of India Occasional Papers

Index to Volume 17 (1996)