Development Research Group

Study
No. 24

INTEREST RATE MODELLING AND FORECASTING IN INDIA

Pami Dua
Nishita Raje
Satyananda Sahoo

Department of Economic Analysis and Policy
Reserve Bank of India
Mumbai

October 20, 2003

Printed at Work Center Offset Printers (I) Pvt. Ltd., A-2 / 32, 41, Shah & Nahar Indl.
Estate, Lower Parel, Mumbai - 400 013. Tel.: 2492 9261 / 2494 3227

ACKNOWLEDGEMENTS

We are deeply indebted to Dr. Y. V. Reddy, then Deputy Governor and now Governor for giving us the opportunity to undertake the project on “Interest Rate Modelling and Forecasting in India”. Special thanks are also due to Dr. Rakesh Mohan, Deputy Governor, for his keen interest in the project.

We are also very grateful to Dr. Narendra Jadhav, Principal Adviser, Department of Economic Analysis and Policy (DEAP), for insightful discussions and support throughout the project. We also gratefully acknowledge and appreciate invaluable help and support from Shri Somnath Chatterjee, Director, DEAP. His meticulous attention greatly facilitated the completion of the project. We extend our thanks also to Smt. Balbir Kaur, Director, DEAP, New Delhi, for her support and guidance in the initial stages of the project.

The Study was presented at a seminar in the Reserve Bank of India. We are thankful to the discussants, S/Shri. B.K.Bhoi, Indranil Sen Gupta and Indranil Chakraborty, as well as other participants for their invaluable comments. We also thank Shri Sanjay Bose, Director, IDMD, for detailed discussions with the internal team members. We also thank the staff of DRG, Smt. A. A. Aradhye, Smt. Christine D’Souza, Shri N.R. Kotian and Shri B.S. Gawas for extending the necessary help.

We also gratefully acknowledge useful discussions that the external expert had with Nitesh Jain, Gaurav Kapur, and Jitendra Keswani in the initial stages of the project. Finally, we are extremely grateful to Sumant Kumar Rai for competent and skilled research assistance. The external expert is also very grateful to the Centre for Development Economics, Delhi School of Economics for support for this project. We also thank the staff of the Centre for Development Economics, Delhi School of Economics for their help.

CONTENTS

Issued for Discussion

DRG Studies Series

Development Research Group (DRG) has been constituted in the Reserve Bank of India in its Department of Economic Analysis and Policy. Its objective is to undertake quick and effective policy-oriented research backed by strong analytical and empirical basis, on subjects of current interest. The DRG studies are the outcome of collaborative efforts between experts from outside the Reserve Bank and the pool of research talent within the Bank. These studies are released for wider circulation with a view to generating constructive discussion among the professional economists and policy makers.

Director
Development Research Group

Requests relating to DRG studies may be addressed to
Director,
Development Research Group
Department of Economic Analysis and Policy
Reserve Bank of India
Post Box No.1036.
Mumbai - 400 001.

DRG Studies Series

No.	Title	Date
1.	On the Guidelines Relating to Valuation of Shares	February 19, 1992
2.	Monetary Policy, Inflation and Activity in India	April 07, 1992
3.	Gold Mobilisation as an Instrument of External Adjustment	April 21, 1992
4.	The Changing Monetary Process in the Indian Economy	September 14, 1992
5.	Agricultural Policy in India – Context, Issues and Instruments	February 10, 1993
6.	Social Sector Expenditures and Human Development: A Study of Indian States	May 27, 1993
7.	Bridging the Technology Gap: How Dynamic and Far-signted is the Indian Corporate Sector?	July 23, 1993
8.	Stabilisation Policy Option: A Macro – econometric Analysis	April 20, 1994
9.	An Approach to Monetary Targeting in India	October 21, 1994
10.	Analytical Foundations of Financial Programming and Growth Oriented Adjustment	January 18, 1995
11.	Fiscal Efficiency in the Indian Federation	June 19, 1995
12.	Inflation, Interest Rates and Index-Linked Bonds	April 18, 1996
13.	Money Demand Stability: Myth or Reality – An Econometric Analysis	July 22, 1996
14.	Foreign Collaboration Under Liberalisation Policy: Patterns of FDI and Technology - transfer in Indian Industry since 1991	August 30, 1996
15.	EMU, EURO and India	March 12, 1998
16.	Dynamics of Inflation in India: A Neural Network Approach	April 16, 1998
17.	The Impact of the Uruguay Round on Growth And Structure of Indian Economy	December 10, 1998
18.	Portfolio Selection for Management of Foreign Exchange Reserves	June 21, 1999
19.	Bond Financing and Debt Stability: Theoretical Issues and Empirial Analysis for India	June 10, 2000
20.	Productivity in Major Manufacturing Industries in India 1973-74 to 1997-98	August 18, 2000
21.	Modernising Indian Agriculture: Priority Tasks and Critical Policies	August 29, 2000
22.	Capital Adequacy Requirements and Behaviour of Commercial Banks in India: An Analytical and Empirical Study	September 20, 2000
23.	A Leading Index for India's Exports	January 08, 2001

EXECUTIVE SUMMARY

The interest rate is a key financial variable that affects decisions of consumers, businesses, financial institutions, professional investors and policymakers. Movements in interest rates have important implications for the economy's business cycle and are crucial to understanding financial developments and changes in economic policy. Timely forecasts of interest rates can therefore provide valuable information to financial market participants and policymakers. Forecasts of interest rates can also help to reduce interest rate risk faced by individuals and firms. Forecasting interest rates is also very useful to central banks in assessing the overall impact (including feedback and expectation effects) of its policy changes and taking appropriate corrective action, if necessary. In fact, the usefulness of the information contained in interest rates greatly increases particularly with financial sector liberalisation.

In the Indian context, the progressive deregulation of interest rates across a broad spectrum of financial markets was an important constituent of the package of structural reforms initiated in the early 1990s. As part of this process, the Reserve Bank has taken a number of initiatives in developing financial markets, particularly in the context of ensuring efficient transmission of monetary policy.

Against this backdrop, the objective of this study is to develop models to forecast short-term and long-term rates: call money rate, 15-91 days Treasury bill rate and rates on 1-year, 5-years and 10-years government securities. Univariate as well as multivariate models are estimated for each interest rate. Univariate models include Autoregressive Integrated Moving Average (ARIMA) models, and ARIMA models with Autoregressive Conditional Heteroscedasticity (ARCH)/Generalised Autoregressive Conditional Heteroscedasiticity (GARCH) effects while multivariate models include Vector Autoregressive (VAR) models specified in levels, Vector Error Correction Models (VECM), and Bayesian Vector Autoregressive (BVAR) models. In the multivariate models, factors such as liquidity, Bank Rate, repo rate, yield spread, inflation, credit, foreign interest rates and forward premium are considered. The random walk model is used as the benchmark for evaluating the forecast performance of each model.

Evaluation of Forecasting Models

For each interest rate, a search for the "best" forecasting model is conducted. The "best model" is defined as one that produces the most accurate forecasts such that the predicted levels are close to the actual realized values. Furthermore, the predicted variables should move in the same direction as the actual series. In other words, if a series is rising (falling), the forecasts should reflect the same direction of change. If a series is changing direction, the forecasts should also identify this. To select the best model, the alternative models are initially estimated using weekly data over the period April 1997 through December 2001 and out-of-sample forecasts up to 36-weeks-ahead are made from January through September 2002. In other words, by continuously updating and reestimating, a real world forecasting exercise is conducted to see how the models perform.

Main Findings for Each Interest Rate

The variables employed in the multivariate models as well as the specific conclusions with respect to the various interest rates are given below.

Call money rate

- The multivariate models for the call money rate include the following: inflation rate (week-to-week), Bank Rate, yield spread, liquidity, foreign interest rate (3-months Libor), and forward premium (3-months).

- Evaluation of out-of-sample forecasts for the call money rate suggests that an ARMA-GARCH model is best suited for very short-term forecasting while a BVAR model with a loose prior can be used for longer-term forecasting.

Treasury Bill rate (15-91 days)

The following variables are included in the multivariate models for the Treasury Bill rate (15-91 days): inflation rate (year-on-year), Bank Rate, yield spread, liquidity, foreign interest rate (3-months Libor), and forward premium (3-months).

- In the case of the 15-91 day Treasury Bill rate, the VAR model in levels produces the most accurate short- and long-term forecasts.

Government Security 1 year

- The multivariate models for 1 year government securities utilize the following variables: inflation rate (year-on-year), Bank Rate; yield spread, liquidity, foreign interest rate (6-months Libor), forward premium (6-months).

- The performance of the out-of-sample forecasts for 1-year government securities indicates that BVAR models out-perform the alternatives at the short and long ends.

Government Security 5 years

- The multivariate models for 5 years government securities include the following: inflation rate (year-on-year), Bank Rate; yield spread, credit, foreign interest rate (6-months Libor), and forward premium (6-months).

- For 5-year government securities, the BVAR models do not perform well. Overall, VECM outperforms all the alternative models. VECM also generally outperforms the alternatives at the short and long run forecast horizons.

Government Security 10 years

- The following variables are used in the multivariate models for 10 years government securities: inflation rate (year-on-year), Bank Rate, yield spread, credit, foreign interest rate (6-months Libor), and forward premium (6-months).

- The forecasting performance of all the models is satisfactory for 10-year government securities. The model that produces the most accurate forecasts is a VAR in levels (LVAR); in other words, a BVAR with a very loose prior. The LVAR model also produces the most accurate short- and long-term forecasts.

The selected models conform to expectations. Standard ARIMA models are based on a constant residual variance. Since financial time series are known to exhibit volatility clustering, this effect is taken into account by estimating ARCH/GARCH models. It is found that although the ARCH/GARCH effects are significant, the ARCH model produces more accurate out-of-sample forecasts relative to the corresponding ARIMA model only in the case of call money rate. This result is not surprising since the out-of sample period over which the alternative models are evaluated is relatively stable with no marked swing in the interest rates.

It is also found that the multivariate models generally produce more accurate forecasts over longer forecast horizons. This is because interactions and dependencies between variables become stronger for longer horizons. In other words, for short forecast horizons, predictions that depend solely on the past history of a variable may yield satisfactory results.

In the class of multivariate models, the Bayesian model generally outperforms its contenders. Unlike the VAR models, the Bayesian models are not adversely affected by degree of freedom constraints and overparameteiztion. In two cases, i.e., for TB 15-

91 and GSec 10, the level VAR performs best suggesting that a loose prior is more appropriate for these models. Notice that with a loose prior, the Bayesian model approaches the VAR model with limited restrictions on the coefficients.

The VECM model outperforms the others only in the case of the GSec 5-years rate. Although inclusion of an error correction term in a VAR is generally expected to improve forecasting performance if the variables are indeed cointegrated, this contention did not find support in this study. This may be because cointegration is a long run phenomenon and the span of the estimation period in this study is not sufficiently large to permit a rigorous analysis of the long-run relationships. Thus, it is not surprising that the VAR models generally outperform the corresponding VECM forecasts.

Thus, to sum up, the forecasting performance of BVAR models for all interest rates is satisfactory. The BVAR models generally produce more accurate forecasts compared to the alternatives discussed in the study and their superiority in performance is marked at longer forecast horizons. The variables included in the optimal BVAR models are: inflation, Bank Rate, liquidity, credit, spread, libor 3-and 6-months and forward premium 3- and 6-months. These variables are selected from a large set of potential series including the repo rate, cash reserve ratio, foreign exchange reserves, exchange rate, stock prices, advance (centre and state government advance by RBI), turnover (total turnover of all maturities), 3- and 6-months US Treasury Bill rate (secondary market), reserve money and its growth rates.

INTEREST RATE MODELLING AND FORECASTING IN INDIA

Pami Dua*
Nishita Raje
Satyananda Sahoo

SECTION I

INTRODUCTION

The interest rate is a key financial variable that affects decisions of consumers, businesses, financial institutions, professional investors and policymakers. Movements in interest rates have important implications for the economy's business cycle and are crucial to understanding financial developments and changes in economic policy. Timely forecasts of interest rates can therefore provide valuable information to financial market participants and policymakers. Forecasts of interest rates can also help to reduce interest rate risk faced by individuals and firms. Forecasting interest rates is very useful to central banks in assessing the overall impact (including feedback and expectation effects) of its policy changes and taking appropriate corrective action, if necessary.

An important constituent of the package of structural reforms initiated in India in the early 1990s, was the progressive deregulation of interest rates across the broad spectrum of financial markets. As part of this process, the Reserve Bank has taken a number of

* Pami Dua is Professor in the Delhi School of Economics, University of Delhi, New Delhi. Nishita Raje and Satyananda Sahoo are Assistant Adviser and Research Officer, respectively, in the Department of Economic Analysis and Policy, Reserve Bank of India, Mumbai.

initiatives in developing financial markets, particularly in the context of ensuring efficient transmission of monetary policy. An important consideration in this regard is the signaling role of monetary policy and its implications for equilibrium interest rates. Furthermore, the evolvement of a 'multiple indicator approach' to monetary policy formulation has underscored the information content of rate variables to optimize management goals. Besides, with the progressive integration of financial markets, 'shocks' to one market can have quick 'spill- over' effects on other markets. In particular, with the liberalization of the external sector, the vicissitudes of capital flows can have implications for the orderly movement of domestic interest rates. Moreover, given the extant large volume of government's market borrowings and the role of the Reserve Bank in managing the internal debt of the Government, an explicit understanding of the determinants of various interest rates and their expected trajectories over the future could facilitate proper coordination of monetary/interest rate policy, exchange rate policy and fiscal policy.

Against this backdrop, the objective of this study is to develop models to forecast short-term and long-term rates: call money rate, 15-91 days Treasury bill rate and rates on 1-year, 5-year and 10-year government securities. Univariate as well as multivariate models are estimated for each interest rate. Univariate models include Autoregressive Integrated Moving Average (ARIMA) models, and ARIMA models with Autoregressive Conditional Heteroscedasticity (ARCH)/Generalised Autoregressive Conditional Heteroscedasiticity (GARCH) effects while multivariate models include Vector Autoregressive (VAR) models specified in levels, Vector Error Correction Models (VECM) and Bayesian Vector Autoregressive (BVAR) models. In the multivariate models, factors such as liquidity, Bank Rate, repo rate, yield spread, inflation, credit, foreign interest rates and forward premium are considered. The random walk model is used as the benchmark for evaluating the forecast performance of each model.

For each interest rate, a search for the “best” forecasting model, *i.e.*, one that yields the most accurate forecasts is conducted. This search encompasses the evaluation of the performance of the aforementioned alternative forecasting models. Each model is estimated using weekly data from April 1997 through December 2001 and out-of-sample forecasts up to 36-weeks-ahead are made from January through September 2002. The most significant finding is that multivariate models generally perform better than naive and univariate models and that the forecasting performance of BVAR models is satisfactory for all models.

The format of the study is as follows. Section II highlights, as a backdrop to the ensuing discussion, some stylized facts on interest rates in the context of financial sector reforms and the changes in the monetary policy environment in India. Section III describes the conceptual underpinnings of the different models considered. It also reviews the tests for non-stationarity and describes the methodology for comparing the out-of-sample forecast performance of the models. Section IV presents the empirical results of the alternative models and Section V concludes.

SECTION II

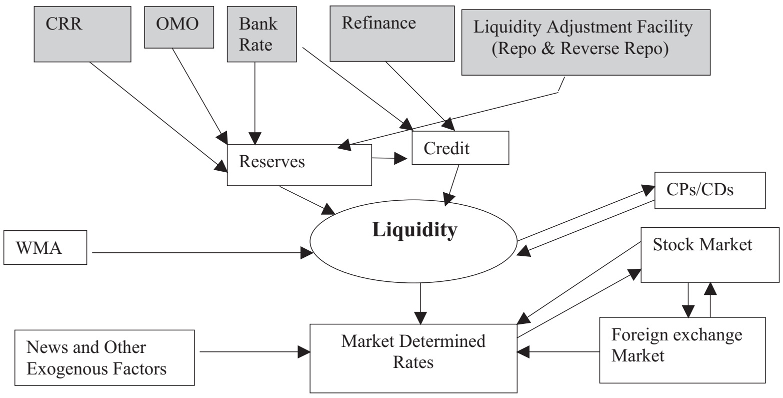
INTEREST RATES AND MONETARY POLICY IN INDIA: SOME STYLIZED FACTS

The role of interest rates in the monetary policy framework has assumed increasing significance with the initiation of financial sector reforms in the Indian economy in the early 1990s and the progressive liberalisation and integration of financial markets. While the objectives of monetary policy in India have, over the years, primarily been that of maintaining price stability and ensuring adequate availability of credit for productive activities in the economy, the monetary policy environment, instruments and operating procedures have undergone significant changes. It is in this context that the Reserve Bank's Working Group on Money Supply (1998) observed that the emergence of rate variables in a liberalised environment has adversely impacted upon the predictive stability of the money demand function (although the function continues to exhibit parametric stability) and thus, monetary policy based solely on monetary targets could lack precision. The Group also underscored the significance of the interest rate channel of monetary transmission in a deregulated environment. This was, in fact, the underlying principle of the multiple indicator approach that was adopted by the Reserve Bank during 1998-99, whereby a set of economic variables (including interest rates) were to be monitored along with the growth in broad money, for monetary policy purposes. Monetary Policy Statements of the Reserve Bank in recent years have also emphasized the preference for a soft and flexible interest rate environment within the framework of macroeconomic stability.

Interest rates across various financial markets have been progressively rationalized and deregulated during the reform period (See Annexure I for Chronology of Reform Measures in respect of Monetary Policy). The reforms have generally aimed towards the easing of quantitative restrictions, removal of barriers to entry, wider participation, increase in the number of instruments and improvements in trading, clearing and settlement practices as well as informational flows. Besides, the elimination of automatic monetisation of government budget deficit, the progressive reduction in statutory reserve requirements and the shift from direct to indirect instruments of monetary control, have impacted upon the structure of financial markets and the enhanced role of interest rates in the system.

The Reserve Bank influences liquidity and in turn, short-term interest rates, via changes in Cash Reserve Ratio (CRR), open market operations, changes in the Bank Rate, modulating the refinance limits and the Liquidity Adjustment Facility (LAF) [Chart I]. The LAF was introduced in June 2000 to modulate short-term liquidity in the system on a daily basis through repo and reverse repo auctions, and in effect, providing an informal corridor for the call money rate. The LAF sets a corridor for the short-term interest rates consistent with policy objectives. The Reserve Bank also uses the private placement route in combination with open market operations to modulate the market-borrowing programme of the Government. In the post – 1997 period, the Bank

Chart I: Determinants of Short-Term Interest Rates in India



CRR: Cash Reserve Ratio; OMO: Open Market Operations; WMA: Ways and Means Advances; CD: Certificates of Deposits; CP: Commercial Paper.

Rate has emerged as a reference rate as also a signaling mechanism for monetary policy actions while the LAF rate has been effective both as a tool for liquidity management as well as a signal for interest rates in the overnight market.

The liquidity in the system is also influenced by 'autonomous' factors like the Ways and Means Advances (WMA) to the Government, developments in the foreign exchange market and stock market and 'news'.

The changes in the financial sector environment have impacted upon the structure and movement of interest rates during the period under consideration (1997-2002). First, the trends in different interest rates (call money, treasury bill and government securities of residual maturities of one, five and ten years or more) are indicative of a general downward movement particularly from 2000 onwards (Charts II A and B), reflecting the liquidity impact of capital inflows and deft liquidity and debt management in the face of large government borrowings. There were, however, two distinct aberrations in the general trend during this period which essentially reflected the impact of monetary policy and other regulatory actions taken to

Chart IIA: Trends in Interest Rates (1997-1998)

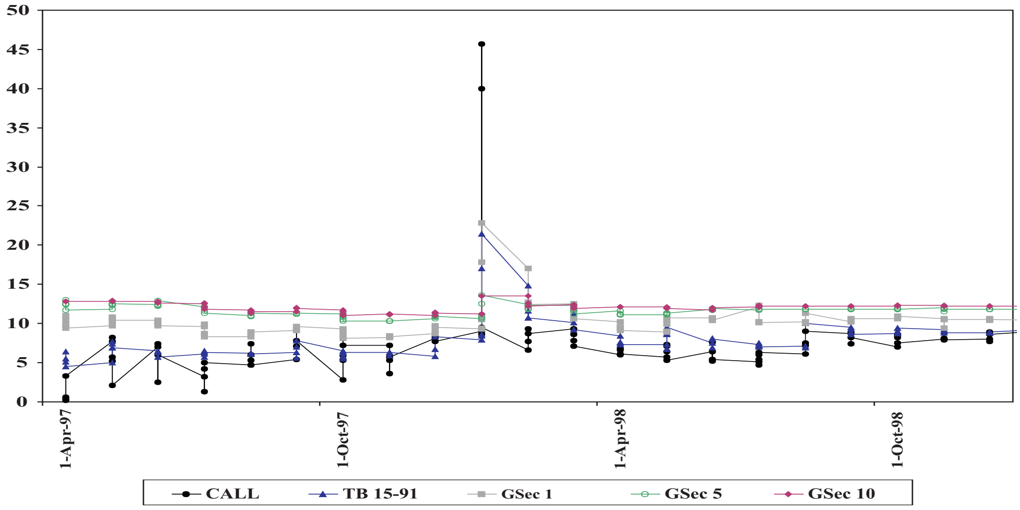
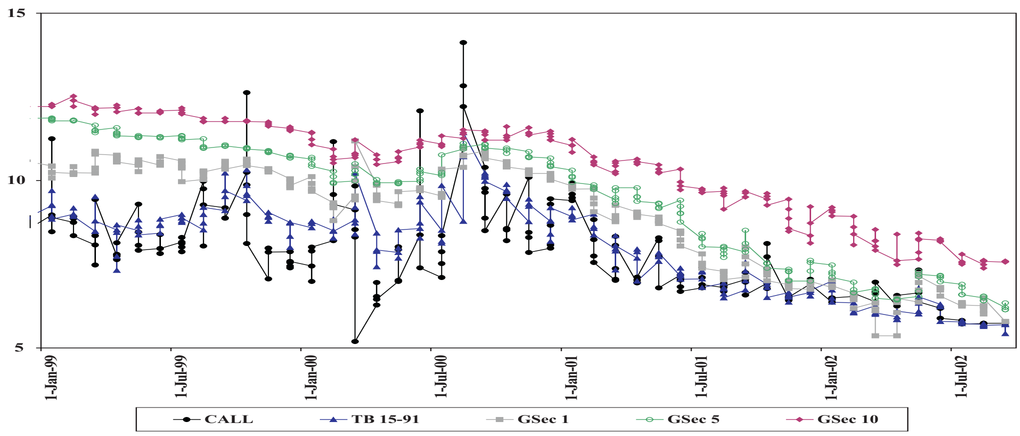


Chart II B: Trends in Interest Rates (1999-2002)



quell exchange market pressures: the first, which occurred in January 1998 in the wake of the financial crisis in South-East Asia was, in fact, very sharp, while the second occurred around May-August 2000.

Second, higher residual maturities have been associated with higher average levels of interest rates (reflecting an upward sloping yield curve) but lower volatility in interest rates (Table 1).

Table 1: Interest Rates – Summary Statistics
(4th Apr 1997-27th Sep 2002)

Interest Rates	Mean	Maximum	Minimum	Standard Deviation
Call	7.67	45.67 (23rd Jan 1998)	0.18 (4th Apr 1997)	3.46
TB15-91	7.97	21.44 (30th Jan 1998)	4.49 (25thApr 1997)	1.76
Gsec1	9.34	22.86 (30th Jan 1998)	5.37 (22nd Mar 2002)	1.90
Gsec5	10.14	13.61 (30th Jan 1998)	1.90 (20th Sep 2002)	1.82
Gsec10	10.95	13.50 (23rd Jan 1998)	7.38 (9th Aug 2002)	1.50

Third, there is evidence of progressive financial market integration as reflected in the co-movement of interest rates, particularly from 2000 onwards. The co-movement in short-term interest rates is exhibited in Charts III (A and B) and Charts IV (A and B). It may be observed that the co-movement in the call market and the three-month forward premium is particularly pronounced during episodes of excessive volatility in foreign exchange markets. Empirical exercises, as discussed subsequently, also indicate that while the impact of monetary policy changes has been readily transmitted across the shorter end of different markets, their impact on the longer end of the markets has been more limited.

Chart III A: Trends in Call Rates, Treasury Bill Rates, Repo Rates and Bank Rate (1997-1998)

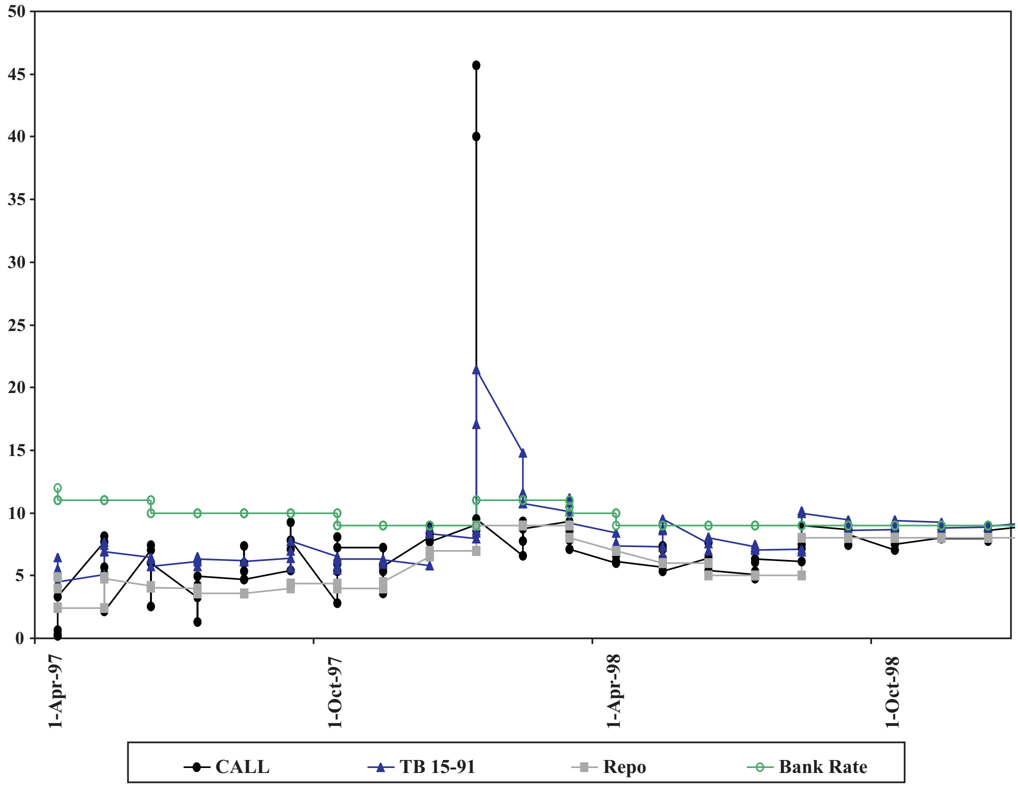


Chart III B: Trends in Call Rates, Treasury Bill Rates, Repo Rates and Bank Rate (1999-2002)

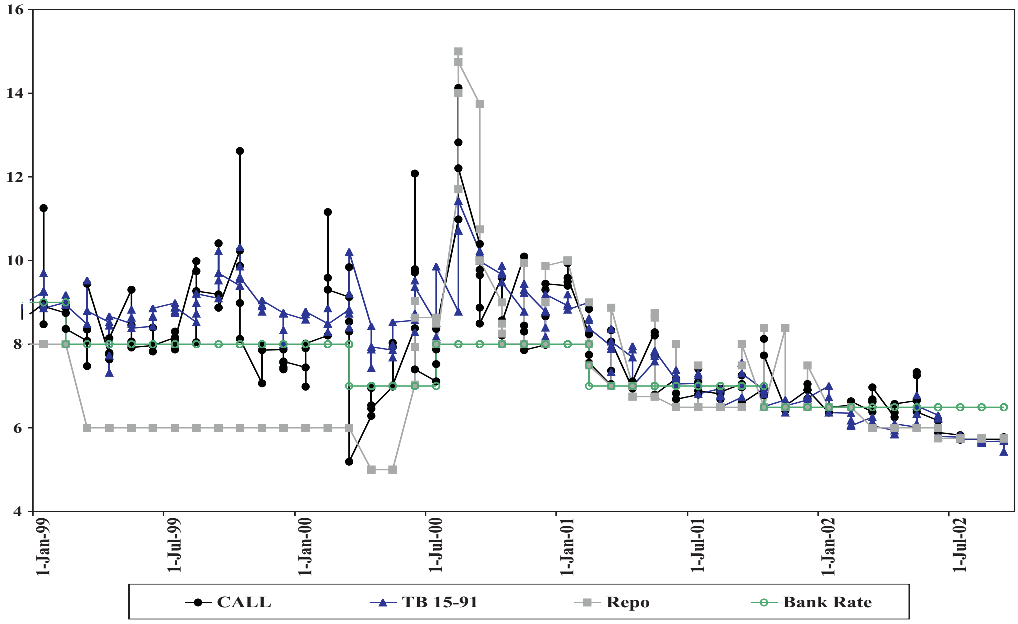


Chart IV A: Trends in Call Rates, Treasury Bill Rates, Government Security (1 year) and Forward Premium (1997-1998)

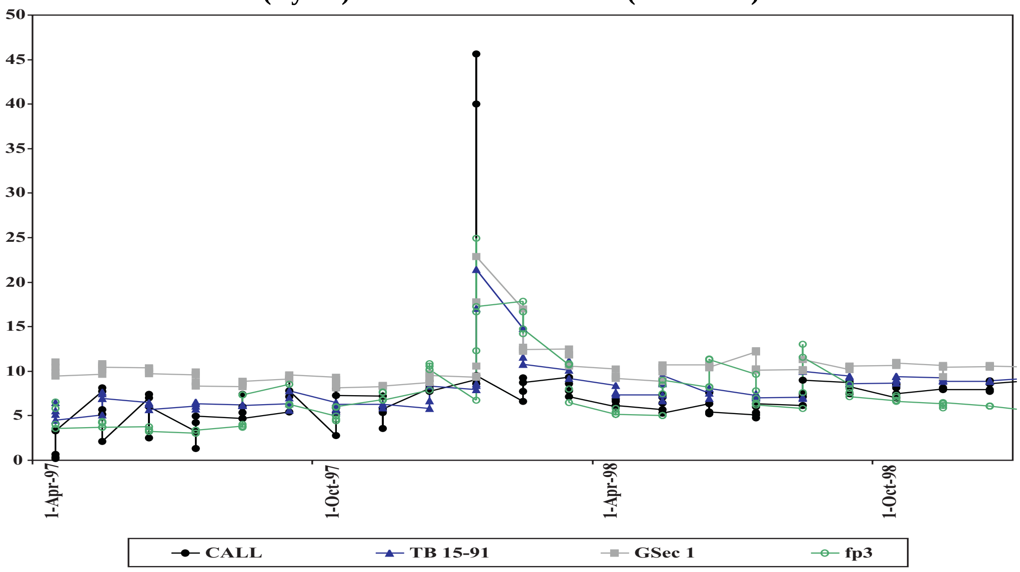
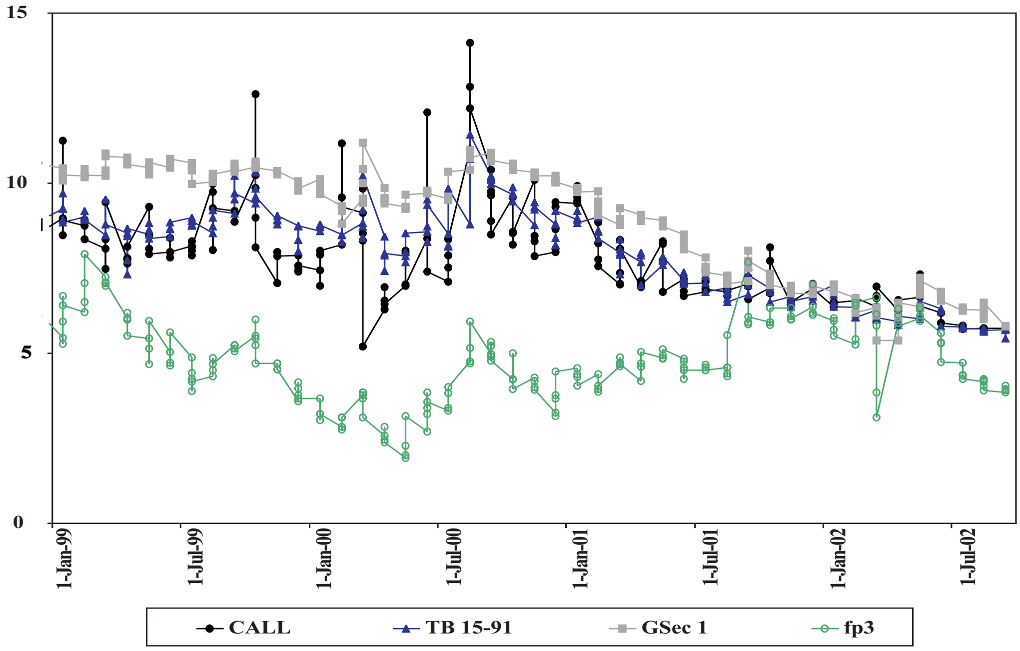


Chart IV B: Trends in Call Rates, Treasury Bill Rates, Government Security (1 year) Rate and Forward Premium (1999-2002)



The co-movement between various interest rates could also be gauged by their correlations (Table 2). The correlation between the Bank Rate and other interest rates is found to increase with the length of the maturity period; this is in contrast to the correlations observed in case of the repo rate and, to some extent, the call money rate. The Treasury Bill rate and the rates on Government securities of one, three and ten-year maturities, are found to be highly correlated.

Table 2 also reports the correlations between interest rates and a few other variables some of which have been included in the multivariate models discussed subsequently. Expectedly, both liquidity and credit are negatively correlated with interest rates and the magnitude of the correlation increases with the maturity period. In the context of the observed negative correlation between credit and interest rates, it may be noted that the notion of 'credit' here refers to credit supply rather than demand. Similarly, the correlation between the year-on-year inflation rate and interest rates is positive and increases with the maturity period of the securities. The yield spread shows a (weak) negative correlation with the call money rate and the Treasury Bill rate, and positive and increasing correlation with interest rates on longer term Government securities. It is also observed that the (positive) correlation of LIBOR rates (both 3-month and 6-month) with domestic interest rates increases with the length of the maturity period in sharp contrast to the correlation between forward premia and domestic interest rates.

Table 2: Correlation-Matrix

(4th Apr 1997-27th Sep 2002)

	Call	**TB15-91**	**GSec 1**	**GSec5**	**Gsec10**
Call	1.000				
TB15-91	0.503	1.000			
GSec 1	0.355	0.837	1.000		
GSec5	0.159	0.528	0.846	1.000	
Gsec10	0.164	0.456	0.839	0.984	1.000
Bank Rate	0.089	0.277	0.649	0.821	0.804
Repo Rate	0.339	0.565	0.252	0.044	0.036
Inflation (yr-on-yr)	0.116	0.322	0.417	0.450	0.425
Inflation(wk-to-wk)	-0.070	-0.014	0.026	0.054	0.017
Yield Spread	-0.105	-0.022	0.410	0.588	0.609
Liquidity	-0.083	-0.270	-0.646	-0.875	-0.868
Credit	-0.073	-0.295	-0.671	-0.907	-0.906
Libor 3-month	0.191	0.511	0.725	0.847	0.827
Libor 6-month	0.185	0.498	0.715	0.840	0.820
FP 3-month	0.440	0.440	0.444	0.238	0.232
FP 6-month	0.324	0.386	0.448	0.313	0.308

SECTION III

ALTERNATIVE FORECASTING MODELS: A BRIEF OVERVIEW

Predicting the interest rate is a difficult task since the forecasts depend on the model used to generate them. Hence, it is important to study the properties of forecasts generated from different models and select the "best" on the basis of an objective criterion. The aim of this study is to select the "best" model for each interest rate from a number of alternative models estimated[1].

The ***benchmark model*** for each interest rate is a ***naïve model*** that implies that the projection for the next period is simply the actual value of the variable in the current period. The naïve model is essentially a random walk as described below:

$$i_t = i_{t-1} + \varepsilon_t$$

with $E(\varepsilon_t)=0$ and $E(\varepsilon_t \varepsilon_s)=0$ for $t \neq s$.

The one-period-ahead forecast is simply the current value as shown below:

$$i^e_{t+1} = E(i_t + \varepsilon_{t+1}) = i_t$$

Similarly the k- period-ahead forecast is:

$$i^e_{t+k} = i_t$$

[1] Fauvel, Paquet and Zimmermann (1999) provide a survey of major methods used to forecast interest rates as well as a review of interest rate modelling. Examples of studies that examine forecasting of interest rates are as follows: Ang and Bekaert (1998); Barkoulas and Baum (1997); Bidarkota (1998); Campbell and Shiller (1991); Chiang and Kahl (1991); Cole and Reichenstein (1994); Craine and Havenner.(1988); Deaves (1996); Dua (1988); Froot (1989); Gosnell (1997); Gray (1996); Hafer, Hein and MacDonald (1992); Holden and Thompson (1996); Iyer and Andrews (1999); Jondeau and Sedillot (1999); Jorion and Mishkin (1991); Kolb and Stekler (1996); Park and Switzer (1997); Pesando (1981); Prell (1973); Roley (1982); Sola and Driffil (1994); and Throop (1981).

The next step is to estimate ARIMA models that predict future values of a variable exclusively on the basis of its own past history. These models are then extended to include ARCH/GARCH effects. Clearly, univariate models are not ideal since these do not use information on the relationships between different economic variables. These are, however, a good starting point since predictions from these models can be compared with those from multivariate models.

III.1. ARIMA Models

An ARIMA(p,d,q) can be represented as:

$\varphi(L)(1-L)^d y_t = \delta + \theta(L)\varepsilon_t$ where L = backward shift operator

$\varphi(L)$ = autoregressive operator $= 1-\varphi_1 L - \varphi_2 L^2 - \ldots\ldots\ldots - \varphi_p L^p$

$\theta(L)$ = moving average operator $= 1-\theta_1 L - \theta_2 L^2 - \ldots\ldots - \theta_q L^q$

The stationarity condition for an AR(p) process implies that the roots of $\varphi(L)$ lie inside the unit circle, i.e., all the roots of $\varphi(L)$ are less than one in absolute value. Restrictions are also imposed on $\theta(L)$ to ensure invertibility so that the MA(q) part can be written in terms of an infinite autoregression on y. Furthermore, if a series requires differencing 'd' times to yield a stationary series, then the differenced series is modelled as an ARMA(p,q) process or equivalently, an ARIMA(p,d,q) model is fitted to the series.

Other criteria employed to select the best-fit model include parameter significance, residual diagnostics, and minimization of the Akaike Information Criterion and the Schwartz Bayesian Criterion.

ARIMA-ARCH/GARCH Models

The assumption of constant variance of the innovation process in the ARIMA model can be relaxed following Engle's (1982) seminal paper and its extension by Bollerslev (1986) on modelling the conditional variance of the error process. One possibility is to model the conditional variance as an AR(q) process using the square of the estimated residuals, i.e., the autoregressive conditional heteroscedasticity (ARCH) model. The conditional variance thus follows an MA process, while in its generalized version – GARCH – it follows an ARMA process. Adding this information can improve the performance of the ARIMA model due to the presence of the volatility clustering effect characteristic of financial series. In other words, the errors, ε_t although serially uncorrelated through the white noise assumption, are not independent since they are related through their second moments. Hence, large values of ε_t are likely to be followed by large values of ε_{t+1} of either sign. Consequently, a realisation of ε_t exhibits behaviour in which clusters of large observations are followed by clusters of small ones.

According to Engle's basic ARCH model, the conditional variance of the shock that occurs at time t is a linear function of the squares of the past shocks. For example, an ARCH(1) model is specified as:

$$Y_t = E\ [Y_t\ |\Omega_{t-1}] + \varepsilon_t$$

$$\varepsilon_t = v_t \sqrt{h_t} \text{ and } h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1}$$

where v_t is a white noise process and is independent of ε_{t-1} and ε_t has mean of zero and is uncorrelated. For the conditional variance h_t to be non-negative, the conditions $\alpha_0 > 0$ and $\alpha_1 \geq 0$ and $0 \leq \alpha_1 \leq 1$ (for covariance stationarity) must be satisfied. To understand why the ARCH model can describe volatility clustering, observe that the above equations show that the conditional variance of ε_t is an increasing function of the shock that occurred in the previous time periods. Therefore if ε_{t-1} is large (in absolute value), ε_t is expected to be large (in absolute value) as well. In other words, large (small) shocks tend to be followed by large (small) shocks, of either sign.

To model extended persistence, generalizations of the ARCH(1) model such as including additional lagged squared shocks can be considered as in the ARCH (q) model below:

$$h_t = \alpha_0 + \alpha_1\varepsilon^2_{t-1}+\alpha_2\varepsilon^2_{t-2}+.....+\alpha_q\varepsilon^2_{t-q}$$

For non-negativeness of the conditional variance, the following conditions must be met: $\alpha_0 > 0$, $\alpha_1 > 0$ and $1 > \Sigma_i\alpha_i \geq 0$ for all $i = 1,2,3, ..., q$.

To capture the dynamic patterns in conditional volatility adequately by means of an ARCH (q) model, q often needs to be quite large. Estimating the parameters in such a model can therefore be cumbersome because of stationarity and non-negativity constraints. However, adding lagged conditional variances to the ARCH model can circumvent this drawback. For example, including h_{t-1} to the ARCH (1) model, results in the Generalized ARCH (GARCH) model of the order (1,1):

$$h_t = \alpha_0 + \alpha_1\varepsilon^2_{t-1}+ \beta_1 h_{t-1}$$

The parameters in this model should satisfy $\alpha_0 > 0$, $\alpha_1 > 0$ and $\beta_1 \geq 0$ to guarantee that $h_t \geq 0$, while α_1 must be strictly positive for to β_1 be identified. Generalising, the GARCH (p,q) model is given by:

$$h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon^2_{t-i} + \sum_{i=1}^{p}\beta_i h_{t-i}$$

$$h_t = \alpha_0 + \alpha(L)\ \varepsilon^2_t + \beta(L)\ h_t$$

Assuming that all the roots of $1 - \beta(L)$ are outside the unit circle, the model can be rewritten as an infinite-order ARCH model.

As indicated above, univariate models such as ARIMA and ARCH/GARCH models utilize information only on the past values of the variable to make forecasts. We now consider multivariate forecasting models that rely on the interrelationships between different variables.

III.2. VAR and BVAR Modelling

As a prelude to the discussion on multivariate models, it is apposite to note that according to the Statement on Monetary and Credit Policy for 2002-03, short-term forecasts of interest rates need to take cognizance of possible movements in all other macreconomic variables including investment, output and inflation, which are, in turn, susceptible to unanticipated changes emanating from unforseen domestic or international developments. Multivariate forecasting models address such concerns and are often formulated as simultaneous equations structural models. In these models, economic theory not only dictates what variables to include in the model, but also postulates which explanatory variables to use to explain any given independent variable. This can, however, be problematic when economic theory is ambiguous. Further, structural models are generally poorly suited for forecasting. This is because projections of the exogenous variables are required to forecast the endogenous variables. Another problem in such models is that proper identification of individual equations in the system requires the correct number of excluded variables from an equation in the model.

A vector autoregressive (VAR) model offers an alternative approach, particularly useful for forecasting purposes. This method is multivariate and does not require specification of the projected values of the exogenous variables. Economic theory is used only to determine the variables to include in the model.

Although the approach is “atheoretical,” a VAR model approximates the reduced form of a structural system of simultaneous equations. As shown by Zellner (1979), and Zellner and Palm (1974), any linear structural model theoretically reduces to a VAR moving average (VARMA) model, whose coefficients combine the structural coefficients. Under some conditions, a VARMA model can be expressed as a VAR model and as a Vector Moving Average (VMA) model. A VAR model can also approximate the reduced form of a simultaneous structural model. Thus, a VAR model does not totally differ from a large-scale structural model. Rather, given the correct restrictions on the parameters of the VAR model, they reflect mirror images of each other.

The VAR technique uses regularities in the historical data on the forecasted variables. Economic theory only selects the economic variables to include in the model. An unrestricted VAR model (Sims 1980) is written as follows:

y_t = $C + A(L)y_t + e_t$, where

y = an (nx1) vector of variables being forecast;

$A(L)$ = an (nxn) polynomial matrix in the back-shift operator L with lag length p,

= $A_1L + A_2L^2 + \ldots\ldots\ldots\ldots + A_pL^p$;

C = an (nx1) vector of constant terms; and

e = an (nx1) vector of white noise error terms.

The model uses the same lag length for all variables. One serious drawback exists — overparameterization produces multicollinearity and loss of degrees of freedom that can lead to inefficient estimates and large out-of-sample forecasting errors. One solution excludes insignificant variables/lags based on statistical tests.

An alternative approach to overcome overparameterization uses a Bayesian VAR model as described in Litterman (1981), Doan, Litterman and Sims (1984), Todd (1984), Litterman (1986), and Spencer (1993). Instead of eliminating longer lags and/or less important variables, the Bayesian technique imposes restrictions on these coefficients on the assumption that these are more likely to be near zero than the coefficients on shorter lags and/or more important variables. If, however, strong effects do occur from longer lags and/or less important variables, the data can override this assumption. Thus the Bayesian model imposes prior beliefs on the relationships between different variables as well as between own lags of a particular variable. If these beliefs (restrictions) are appropriate, the forecasting ability of the model should improve. The Bayesian approach to forecasting therefore provides a scientific way of imposing prior or judgmental beliefs on a statistical model. Several prior beliefs can be imposed so that the set of beliefs that produces the best forecasts is selected for making forecasts. The selection of the Bayesian prior, of course, depends on the expertise of the forecaster.

The restrictions on the coefficients specify normal prior distributions with means zero and small standard deviations for all coefficients with decreasing standard deviations on increasing lags, except for the coefficient on the first own lag of a variable that is given a mean of unity. This so-called "Minnesota prior" was developed at the Federal Reserve Bank of Minneapolis and the University of Minnesota.

The standard deviation of the prior distribution for lag m of variable j in equation i for all i, j, and m — $S(i, j, m)$ — is specified as follows:

$$S(i, j, m) = \{wg(m)f(i, j)\}s_i/s_j;$$

$$f(i, j) = 1, \text{ if } i = j;$$

$$= k \text{ otherwise } (0 < k < 1); \text{ and}$$

$$g(m) = m^{-d}, d > 0.$$

The term s_i equals the standard error of a univariate autoregression for variable i. The ratio s_i/s_j scales the variables to account for differences in units of measurement and allows the specification of the prior without consideration of the magnitudes of the variables. The parameter w measures the standard deviation on the first own lag and describes the overall tightness of the prior. The tightness on lag m relative to lag 1 equals the function $g(m)$, assumed to have a harmonic shape with decay factor d. The tightness of variable j relative to variable i in equation i equals the function $f(i, j)$.

To illustrate, assume the following hyperparameters: $w = 0.2$; $d = 2.0$; and $f(i, j) = 0.5$. When $w = 0.2$, the standard deviation of the first own lag in each equation is 0.2, since $g(1) = f(i, j) = s_i / s_j = 1.0$. The standard deviation of all other lags equals $0.2[s_i / s_j\{g(m)f(i, j)\}]$. For $m = 1, 2, 3, 4$, and $d = 2.0$, $g(m) = 1.0, 0.25, 0.11, 0.06$, respectively, showing the decreasing influence of longer lags. The value of $f(i, j)$ determines the importance of variable j relative to variable i in the equation for variable i, higher values implying greater interaction. For instance, $f(i, j) = 0.5$ implies that relative to variable i, variable j has a weight of 50 percent. A tighter prior occurs by decreasing w, increasing d, and/or decreasing k. Examples of selection of hyperparameters are given in Dua and Ray (1995), Dua and Smyth (1995), Dua and Miller (1996) and Dua, Miller and Smyth (1999).

The BVAR method uses Theil's (1971) mixed estimation technique that supplements data with prior information on the distributions of the coefficients. With each restriction, the number of observations and degrees of freedom artificially increase by one. Thus, the loss of degrees of freedom due to overparameterization does not affect the BVAR model as severely.

Another advantage of the BVAR model is that empirical evidence on comparative out-of-sample forecasting performance generally shows that the BVAR model outperforms the unrestricted VAR model. A few examples are Holden and Broomhead (1990), Artis and Zhang (1990), Dua and Ray (1995), Dua and Miller (1996), Dua, Miller and Smyth (1999).

The above description of the VAR and BVAR models assumes that the variables are stationary. If the variables are nonstationary, they can continue to be specified in levels in a BVAR model because as pointed out by Sims et. al (1990, p.136) '......the Bayesian approach is entirely based on the likelihood function, which has the same Gaussian shape regardless of the presence of nonstationarity, [hence] Bayesian inference need take no special account of nonstationarity'. Furthermore, Dua and Ray (1995) show that the Minnesota prior is appropriate even when the variables are cointegrated.

In the case of a VAR, Sims (1980) and others, e.g. Doan (1992), recommend estimating the VAR in levels even if the variables contain a unit root. The argument against differencing is that it discards information relating to comovements between the variables such as cointegrating relationships. The standard practice in the presence of a cointegrating relaionship between the variables in a VAR is to estimate the VAR in levels or to estimate its error correction representation, the vector error correction model (VECM). If the variables are nonstationary but not cointegrated, the VAR can be estimated in first differences.

The possibility of a cointegrating relationship between the variables is tested using the Johansen and Juselius (1990) methodology as follows.

Consider the p-dimensional vector autoregressive model with Gaussian errors

$$y_t = A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + \Psi.D_t + A_0 + \varepsilon_t$$

where y_t is mx1 an vector of I(1) jointly determined variables, D is a vector of deterministic or nonstochastic variables, such as seasonal dummies or time trend. The Johansen test assumes that the variables in y_t are I(1). For testing the hypothesis of cointegration the model is reformulated in the vector error-correction form:

$$\Delta y_t = -\Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + A_0 + \Psi D_t + \varepsilon_t$$

where

$$\Pi = I - \sum_{i=1}^{p} A_i, \qquad \Gamma_i = -\sum_{j=i+1}^{p} A_j, \qquad i = 1,\ldots\ldots, p-1.$$

Here the rank of Π is equal to the number of independent cointegrating vectors. Thus, if the rank $(\Pi)=0$, then the above model will be the usual VAR model in first differences. Similarly, if the vector y_t is I(0), i.e., if all the variables are stationary, then all characteristic roots will be greater than unity and hence Π will be a full rank *m* x *m* matrix. If the elements of vector y_t are I(1) and cointegrated with rank $(\Pi)=r$, then $\Pi = \alpha\beta'$ where α and β are *m* x *r* full column rank matrices and there are $r < m$ linear combinations of y_t. The model can easily be extended to include a vector of exogenous I(1) variables.

Suppose the *m* characteristic roots of Π are $\lambda_1, \lambda_2, \lambda_3 \ldots \lambda_m$. If the variables in y_t are not cointegrated, the rank of Π is zero and all these characteristic roots will be equal zero. Since ln(1)=0, $\ln(1-\lambda_i)$ will be equal to zero if the variables are not cointegrated. Similarly, if the rank of Π is unity, then if $0 < \lambda_1 < 1$ so that $\ln(1-\lambda_1)$ will be negative and $\lambda_i = 0$ ($\forall i > 1$) so that $\ln(1-\lambda_i) = 0$ ($\forall i > 1$).

λ_{trace} and λ_{max} tests can be used to test for the number of characteristic roots that are significantly different from unity.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right)$$

$$\lambda_{max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right)$$

where $\hat{\lambda}_i$ = the estimated values of the characteristic roots of Π

T = the number of usable observations

λ_{trace} tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to *r* against a general alternative. If λ_i=0 for all *i*, then λ_{trace} equals zero. The further the estimated characteristic roots are from zero, the more negative is ln(1-λ_i) and the larger the λ_{trace} statistic. λ_{max} tests the null that the number of cointegrating vectors is *r* against the alternative of *r*+1 cointegrating vectors. If the estimated characteristic root is close to zero, λ_{max} will be small. Since λ_{max} test has sharper alternative hypothesis, it is used to select the number of cointegrating vectors in this study.

Under cointegration, the VECM can be represented as

$$\Delta y_t = -\alpha\beta' y_{t-1} + \sum_{i=1}^{p-1}\Gamma_i \Delta y_{t-1} + A_0 + \Psi D_t + \varepsilon_t$$

where α is the matrix of adjustment coefficients. If there are non-zero cointegrating vectors, then some of the elements of α must also be non-zero to keep the elements of y_t from diverging from equilibrium.

The concept of Granger causality can also be tested in the VECM framework. For example, if two variables are cointegrated, i.e. they have a common stochastic trend, causality in the Granger (temporal) sense must exist in at least one direction (Granger, 1986; 1988). Since Granger causality is also a test of whether one variable can improve the forecasting performance of another, it is important to test for it to evaluate the predictive ability of a model.

In a two variable VAR model, assuming the variables to be stationary, we say that the first variable does not Granger cause the second if the lags of the first variable in the VAR are jointly not significantly different from zero. This concept is extended in the framework of a VECM to include the error correction term in addition to lagged variables. Granger-causality can then be tested by (i) the statistical significance of the lagged error correction term by a standard t-test; and (ii) a joint test applied to the significance of the sum of the lags of each explanatory variables, by a joint F or Wald χ^2 test. Alternatively, a joint test of all the set of terms described in (i) and (ii) can be conducted by a joint F or a Wald χ^2 test. The third option is used in this paper.

III.3. Testing for Nonstationarity

Before estimating any of the above models, the first econometric step is to test if the series are nonstationary or contain a unit root. Several tests have been developed to test for the presence of a unit root. In this study, we focus on the augmented Dickey-Fuller (1979, 1981) test, the Phillips-Perron (1988) test and the KPSS test proposed by Kwiatkowski et al. (1992).

To test if a sequence y_t contains a unit root, three different regression equations are considered.

$$\Delta y_t = \alpha + \gamma y_{t-1} + \theta t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (1)$$

$$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (2)$$

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (3)$$

The first equation includes both a drift term and a deterministic trend; the second excludes the deterministic trend; and the third does not contain an intercept or a trend term. In all three equations, the parameter of interest is γ. If γ=0, the y_t sequence has a unit root. The estimated t-statistic is compared with the appropriate critical value in the Dickey-Fuller tables to determine if the null hypothesis is valid. The critical values are denoted by τ_{τ}, τ_{μ} and τ for equations (1), (2) and (3), respectively.

Following Doldado, Jenkinson and Sosvilla-Rivero (1990), a sequential procedure is used to test for the presence of a unit root when the form of the data-generating process is unknown. Such a procedure is necessary since including the intercept and trend term reduces the degrees of freedom and the power of the test implying that we may conclude that a unit root is present when, in fact, this is not true. Further, additional regressors increase the absolute value of the critical value making it harder to reject the null hypothesis. On the other hand, inappropriately omitting the deterministic terms can cause the power of the test to go to zero (Campbell and Perron, 1991).

The sequential procedure involves testing the most general model first (equation 1). Since the power of the test is low, if we reject the null hypothesis, we stop at this stage and conclude that there is no unit root. If we do not reject the null hypothesis, we proceed to determine if the trend term is significant under the null of a unit root. If the trend is significant, we retest for the presence of a unit root using the standardised normal distribution. If the null of a unit root is not rejected, we conclude that the series contains a unit root. Otherwise, it does not. If the trend is not significant, we estimate equation (2) and test for the presence of a unit root. If the null of a unit root is rejected, we conclude that there is no unit root and stop at this point. If the null is not rejected, we test for the significance of the drift term in the presence of a unit root. If the drift term is significant, we test for a unit root using the standardised normal distribution. If the drift is not significant, we estimate equation (3) and test for a unit root.

We also conduct the Phillips-Perron (1988) test for a unit root. This is because the Dickey-Fuller tests require that the error term be serially uncorrelated and homogeneous while the Phillips-

Perron test is valid even if the disturbances are serially correlated and heterogeneous. The test statistics for the Phillips-Perron test are modifications of the t-statistics employed for the Dickey-Fuller tests but the critical values are precisely those used for the Dickey-Fuller tests. In general, PP test is preferred to the ADF tests if the diagnostic statistics from the ADF regressions indicate autocorrelation or heteroscedasticity in the error terms. Phillips and Perron (1988) also show that when the disturbance term has a positive moving average component, the power of the ADF tests is low compared to the Phillips-Perron statistics so that the latter is preferred. If, however, a negative moving average term is present in the error term, the PP test tends to reject the null of a unit root and, therefore, ADF tests are preferred.

In both the ADF and the PP test, the unit root is the null hypothesis. A problem with classical hypothesis testing is that it ensures that the null hypothesis is not rejected unless there is strong evidence against it. Therefore these tests tend to have low power, that is, these tests will often indicate that a series contains a unit root. Kwiatkowski et al. (1992), therefore, suggest that, based on classical methods, it may be useful to perform tests of the null hypothesis of stationarity in addition to tests of the null hypothesis of a unit root. Tests based on stationarity as the null can then be used for confirmatory analysis, that is, to confirm conclusions about unit roots. Of course, if tests with stationarity as the null as well as tests with unit root as the null, both reject or fail to reject the respective nulls, there is no confirmation of stationarity or nonstationarity.

KPSS test with the null hypothesis of difference stationarity

To test for difference stationarity (DS), KPSS assume that the series y_t with T observations (t=1,2,...,T) can be decomposed into the sum of a deterministic trend, random walk and stationary error:

$$y_t = \delta t + r_t + \varepsilon_t$$

where r_t is a random walk

$$r_t = r_{t-1} + \mu_t$$

and μ_t is independently and identically distributed with mean zero and variance σ^2_μ. The initial value r_0 is fixed and serves the role of an intercept. The stationarity hypothesis is $\sigma^2_\mu=0$. If we set $\delta = 0$, then under the null hypothesis y_t is stationary around a level (r_0).

Let the residuals from the regression of y_t on an intercept be e_t, t=1,2,...,T. The partial sum process of the residuals is defined as:

$$S_t = \sum_{i=1}^{t} e_t.$$

The long run variance of the partial error process is defined by KPSS as

$$\sigma^2 = \lim_{T\to\infty} T^{-1}E(S^2_T).$$

A consistent estimator of σ^2, $s^2(l)$, can be constructed from the residuals e_t as

$$s^2(l) = T^{-1}\sum_{t=1}^{T} e^2_t + 2T^{-1}\sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} e_t e_{t-s}$$

where $w(s,l)$ is an optional lag window that corresponds to the selection of a spectral window. KPSS employ the Bartlett window, $w(s,l) = 1-s/(l+1)$ as in Newey and West (1987), which ensures the non-negativity of $s^2(l)$. The lag operator l corrects for residual serial correlation. If the residual series are independently and identically distributed, a choice of $l = 0$ is appropriate.

The test statistic for the DS null hypothesis is

$$\hat{\eta}_{\mu} = T^{-2}\sum_{t=1}^{T} S_t^2/s^2(l).$$

KPSS report the critical values of $\hat{\eta}_{\mu}$ (p. 166) for the upper tail test.

Thus, three tests, augmented Dickey-Fuller, Phillips Perron and KPSS tests, are used to test for the presence of a unit root. The KPSS test, with the null of stationarity, helps to resolve conflicts between ADF and PP tests. If two of these three tests indicate nonstationarity for any series, we conclude that the series has a unit root.

In sum, the study proceeds as follows. First, the series are tested for the presence of a unit root using the augmented Dickey-Fuller, Phillips Perron and KPSS tests. If the interest rate series are nonstationary, univariate models, i.e. ARIMA without and with ARCH-GARCH effects, are fitted to differenced, stationary series.

Multivariate models include VAR, VECM, and BVAR models. To estimate VAR models, if all the variables are nonstationary and integrated of the same order, the Johansen test is conducted for the presence of cointegration. If a cointegrating relationship exists, the VAR model can be estimated in levels. Tests for Granger causality are also conducted in the VECM framework to evaluate the forecasting ability of the model. Lastly, Bayesian vector autoregressive models are estimated that impose prior beliefs on the relationships between different variables as well as between own lags of a particular variable. If these beliefs (restrictions) are appropriate, the forecasting ability of the model should improve.

The forecasting ability of each model is evaluated by examining the performance of out-of-sample forecasts and the "best" forecasting model is selected.

III.4. Evaluation of Forecasting Models

The "best" forecasting model is one that produces the most accurate forecasts. This means that the predicted levels should be close to the actual realized values. Furthermore, the predicted variables should move in the same direction as the actual series. In other words, if a series is rising (falling), the forecasts should reflect the same direction of change. If a series is changing direction, the forecasts should identify this.

To select the best model, the alternative models are initially estimated using weekly data over the period April 1997 to December 2001 and tested for out-of-sample forecast accuracy from January 2002 to September 2002. In other words, by continuously updating and reestimating, we conduct a real world forecasting exercise to see how the models perform. The model that produces the most accurate one- through thirty-six-week-ahead forecasts is designated the "best" model for a particular interest rate.

To test for accuracy, the Theil coefficient (Theil, 1966), is used that implicitly incorporates the naïve forecasts as the benchmark. If A_{t+n} denotes the actual value of a variable in period (t+n), and ${}_tF_{t+n}$ the forecast made in period t for (t+n), then for T observations, the Theil U-statistic is defined as follows:

$$U = [\Sigma(A_{t+n} - {}_tF_{t+n})^2/\Sigma(A_{t+n} - A_t)^2]^{0.5}.$$

The U-statistic measures the ratio of the root mean square error (RMSE) of the model forecasts to the RMSE of naive, no-change forecasts (forecasts such that ${}_tF_{t+n}= A_t$). The RMSE is given by the following formula:

$$RMSE = [\Sigma(A_{t+n} - {}_tF_{t+n})^2/T]^{0.5}.$$

A comparison with the naïve model is, therefore, implicit in the U-statistic. A U-statistic of 1 indicates that the model forecasts match the performance of naïve, no-change forecasts. A U-statistic >1 shows that the naïve forecasts outperform the model forecasts. If U is < 1, the forecasts from the model outperform the naïve forecasts. The U-statistic is, therefore, a relative measure of accuracy and is unit-free.

Since the U-statistic is a relative measure, it is affected by the accuracy of the naïve forecasts. Extremely inaccurate naïve forecasts can yield U <1, falsely implying that the model forecasts are accurate. This problem is especially applicable to series with trend. The RMSE, therefore, provides a check on the U-statistic and is also reported.

To evaluate the forecast performance, the models are continually updated and reestimated. The models are estimated for the initial period April 1997 through December 2001. Forecasts for up to 36-weeks-ahead are computed. One more observation is added to the sample and forecasts up to 36-weeks-ahead are again generated, and so on. Based on the out-of-sample forecasts for the period January through September 2002, the Theil U-statistics and RMSE are computed for one- to 36-weeks-ahead forecasts and the average of successive four U-statistics and RMSE are also computed. The overall average of the U statistic and the RMSE for up to 36-weeks-ahead forecasts is also calculated to gauge the accuracy of a model.

SECTION IV

ESTIMATION OF ALTERNATIVE FORECASTING MODELS

IV.1. Tests for Nonstationarity

The first step in the estimation of the alternative models is to test for nonstationarity. Three alternative tests are used, i.e., the augmented Dickey-Fuller (ADF) test, Phillips Perron (PP) test and the KPSS test. If there is a conflict between the ADF and PP tests, this is resolved using the KPSS test. If at least two of the three tests show the existence of a unit root, the series is considered as nonstationary. The tests for nonstationarity are reported using weekly data from April 1997 to September 2002. Unit root tests are also conducted for a longer time span using monthly data from early 1990s onwards since Shiller and Perron (1985) and Perron (1989) note that when testing for unit roots, the total span of the time period is more important than the frequency of observations. In the same vein, Hakkio and Rush (1991) show that cointegration is a long-run concept and hence requires long spans of data rather than more frequently sampled observations to yield tests for cointegration with higher power. Since the inferences from monthly data conform to those from weekly data, the monthly results are not reported.

Table 1.1A reports the augmented Dickey-Fuller and Phillips Perron tests for the five interest rates under study – call money rate, 15-91 days Treasury Bill rate, and 1, 5, and 10-year government securities (residual maturity). Table 1.1B reports the same tests for variables used in multivariate models while Table 1.2 gives the results of the KPSS test for all the variables used in this study. The results of these three tests are summarised in

Table 1.3 and show that except for the week-to-week inflation rate, all the variables can be treated as nonstationary. Testing for differences of each variable confirms that all the variables are integrated of order one.

IV.2. Estimation of Univariate and Multivariate Models

The univariate best-fit models (Tables 2A-2E) for the first-differenced interest rates are estimated as follows for the period April 1997 to December 2002:

Call money rate:	ARMA (2,2); ARMA(2,2) GARCH(1,1)
Treasury Bill rate – 15-91 days:	ARMA(3,0); ARMA(3,0)-ARCH(1)
Government Securities – 1-year:	ARMA(1,0); ARMA(1,0)-GARCH(1,1)
Government Securities – 5-years:	ARMA(2,0); ARMA(2,0)-ARCH(2)
Government Securities – 10-years:	ARMA(1,0); ARMA(1,0)-ARCH(1)

These models are reported in Tables 2A-2E and are used to generate out-of-sample forecasts from January through September 2002.

Three kinds of multivariate models are estimated – vector autoregressive (VAR) models, vector error correction models (VECM), and Bayesian vector autoregressive (BVAR) models. First, a VAR model is estimated. Second, its error correction representation is derived. Finally, alternative BVAR models are estimated using the optimal lag length determined for an unrestricted VAR.

To estimate a VAR, it is important to first determine if the variables included in a VAR are also cointegrated. If the variables are indeed cointegrated, the VAR model can be estimated in level-form. Accordingly, we first test for cointegration between the variables for each of the interest rates. The optimal lag length for each VAR system is determined by the Akaike Information Criterion, Schwartz Bayesian Criterion and the likelihood ratio test.

Selection of Variables

To estimate the multivariate models, the variables are selected for each model on the basis of economic theory and out-of-sample forecast accuracy. Several factors can impact interest rates. Furthermore, their impacts may differ depending upon the maturity spectrum of the interest rates. For instance, for short-term/medium-term rates, factors that might impact interest rates include monetary policy; liquidity, demand and supply of credit, actual and expected inflation, external factors such as foreign interest rates and change in foreign exchange reserves, and the level of economic activity. For long-term interest rates, demand and supply of funds and expectations about government policy might be relatively more important.

Some of these factors also emerge from the stylized model developed by Dua and Pandit (2002) under covered interest parity condition. The equation for the real interest rate derived from their model can be expressed as a function of expected inflation, foreign interest rate, forward premium, and variables to denote fiscal and monetary effects. Based on this model, the inflation rate, foreign interest rate, forward premium and a variable to gauge monetary policy are included in the forecasting model. In addition to these variables, the following are also included: yield spread (discussed below); liquidity in the monetary system; and a variable to measure credit conditions. Other variables such as CRR, foreign exchange reserves, exchange rate, stock prices, advance, turnover, 3 and 6-months US TB rate (secondary market) and reserve money, were also tried. Since these did not improve the forecast accuracy in any of the equations, these results are not reported. The repo rate is also considered. A detailed comparison between models including Bank Rate and repo rate is given in Tables 7A-7E.

There are, of course, other variables that might impact interest rates such as current and future economic activity and expectations of government policy as mentioned above. However, since the models reported in this study are estimated using weekly data, the selection of variables was obviously circumscribed and, therefore, all of these effects could not be incorporated.

Nevertheless, some of these effects are captured in financial spreads that are measured by differences in the yields on financial assets. These spreads exist due to differences in liquidity, risk and maturity that can also be influenced by factors such as taxes and portfolio regulations. Cyclical changes in any of these factors can arise from monetary policy shifts leading to changes in financial spreads. The most commonly used financial spread is the yield spread whose role in predicting future changes in interest rates is documented in several articles including Campbell and Shiller (1991), Froot (1989), and Sarantis and Lin (1999).

The slope of the yield curve – the difference between the long-term interest rate and the short-term interest rate, measures the yield spread. According to the expectations hypothesis of the term structure, this yield differential provides an indication of the expected future inflation rate (Mishkin, 1989). It also provides a signal about growth in future output. For instance, tight monetary policy and high interest rates can imply a declining yield curve and thus a slowdown in future output growth.

Thus, variables included in the models are: yield spread (10 year Government Security rate minus 3-month Treasury Bill rate); inflation (calculated from Wholesale Price Index using week-to-week changes and year-on-year changes); liquidity in the system (described in Annexure II); credit; Bank Rate/repo rate (indicator of monetary policy); foreign interest rates (Libor 3 months and 6 months); and forward premia (3 months and 6 months). Details of data sources and definitions are given in Annexure II.

The specific variables included in the various models are given below:

Model A:

Call money rate: inflation (week-to-week); Bank Rate; yield spread; liquidity, foreign interest rate (3-month Libor), forward premium (3-months)

Model B:

Treasury Bill rate (15-91 days): inflation (year-on-year), Bank Rate; yield spread, liquidity, foreign interest rate (3-month Libor), forward premium (3-months)

Model C:

Government Security 1 year: inflation (year-on-year), Bank Rate; yield spread, liquidity, foreign interest rate (6-month Libor), forward premium (6-months)

Model D:

Government Security 5 years: inflation (year-on-year), Bank Rate; yield spread, credit, foreign interest rate (6-month Libor), forward premium (6-months)

Model E:

Government Security 10 years: inflation (year-on-year), Bank Rate; yield spread, credit, foreign interest rate (6-month Libor), forward premium (6-months)

In the present context, it is worth noting that the week-to-week inflation rate ($week_{i+1}$ relative to $week_i$) produces better forecasts for the call money rate than year-on-year inflation (week$_{i+52}$ relative to week$_i$) while for all other interest rates, year-on-year inflation produces superior forecasts. This may be because the call money rate is more responsive to week-to-week changes.

The cointegration results are reported in Table 3. A caveat here is that the cointegrating equations are estimated over a short span (five and a half years) and therefore cannot capture the long-run properties of the model. The purpose of estimating the equations is to establish the existence of a cointegrating relationship and thus justify estimating the VAR in levels. Nevertheless, we estimate the error correction model and examine the predictive ability of the variables using Granger causality tests. These results are reported in Table 4 and show that all the variables significantly Granger cause the various interest rates, thus justifying their inclusion in the model.

In addition to the level VAR and VECM models, several Bayesian vector autoregressive models are also estimated. We begin with the prior recommended by Doan (1992), w=0.2, d=1, k=0.5. Four more priors are used to select the optimal prior – i.e., the combination of hyperparameters that yields the most accurate forecasts. Tighter priors compared to Doan (1992) for k=0.5 are: w=0.1, d=1; w=0.1, d=2; and w=0.2, d=2. A looser prior relative to Doan (1992) is obtained by increasing the interaction parameter, k, e.g., k=0.7, w=0.2, d=1.

Tables 5A through 5E report the Theil statistics for the out-of-sample forecasts from January 2002 to September 2002 for all the models while Tables 6A through 6E give the corresponding root mean square errors. The 'optimized' BVAR model for k=0.5, i.e., one that has the lowest overall U statistic is tabulated along with the other models while the remaining BVAR models are tabulated under 'alternative' models. Figures 1A through 1E show the out-of-sample forecasts from the univariate models. Figures 2A through 2E depict the out-of-sample forecasts from the multivariate models while Figures 3A through 3E provide a comparison of the 'best' univariate model vs. the 'best' multivariate model.

Figures 4A through 4E provide insight into multi-horizon forecasts made at the end of January 2002 for up to September 2002. This shows how a real-time forecaster would have performed at the end of January 2002 in predicting interest rates up to September 2002.

IV.3. Main Findings

Call Money Rate (Tables 5A and 6A, Figures 1.1A-1.3A, 2.1A-2.3A, 3.1A-3.3A and 4A)

- ARMA-GARCH model yields more accurate forecasts than the best-fit ARIMA model.
- ARMA-GARCH model outperforms all alternative (univariate and multivariate) models for very short-term forecasts (up to 9-weeks ahead). The model U statistic is < 1 for almost all forecast horizons, which indicates that the model strongly outperforms the random walk.
- Level VAR (LVAR) model provides more accurate forecasts relative to the naïve and other univariate models for more than 9 weeks forecast horizon.
- LVAR model generally provides more accurate forecasts than the Vector Error Correction Model (VECM).
- VECM yields the most inaccurate forecasts.
- BVAR models perform better than LVAR for longer-term forecasts, over 20 weeks ahead.
- Of the BVAR models, the model with a loose prior (w=0.2, d=1 with k fixed at 0.5) outperforms the alternatives. Allowing k to increase (thus increasing the interaction) improves forecast

accuracy. This model is superior to the random walk model for over 8-week-ahead forecasts as reflected in the Theil U statistic.

- The univariate models and VECM generally exhibit an increase in RMSE, i.e., a decrease in forecast accuracy (Table 6A) with an increase in the forecast horizon. On the other hand, the level VAR model almost consistently shows decrease in RMSE while the BVAR models show some improvement in accuracy at the very long end. This is also reflected in Figures 2A, 3A and 4A.

Thus, for the call money rate, an ARMA-GARCH model is best suited for very short-term forecasting while a BVAR model with a loose prior can be used for longer-term forecasting.

Treasury Bill Rate – 15-91 days (Tables 5B and 6B; Figures: 1.1B-1.3B, 2.1B-2.3B, 3.1B-3.3B and 4B)

- ARMA model produces marginally more accurate forecasts compared to the ARMA-ARCH model. However, since the U statistic is greater than or close to 1 for all forecast horizons, the forecast performance is not superior to that of a random walk.
- For all univariate models (including the random walk) there is deterioration in accuracy with an increase in the forecast horizon (Table 6B).
- The LVAR model outperforms the VECM model consistently.
- The LVAR model also beats the BVAR models in terms of forecast accuracy.
- Performance of all BVAR models is reasonable and generally improves on loosening the prior. In the extreme case, with a very loose prior, the BVAR model converges to LVAR.

Therefore, for the 15-91 day Treasury Bill rate, the LVAR models produce the most accurate short- and long-term forecasts.

Government Securities – 1-year (Tables 5C and 6C, Figures 1.1C-1.3C, 2.1C-2.3C, 3.1C-3.3C and 4C)

- ARMA model is generally more accurate than ARMA-GARCH.
- LVAR model almost consistently outperforms VECM forecasts.
- Performance of BVAR forecasts is satisfactory for short- and long-term forecasts and is almost consistently better than that of LVAR.
- Of the BVAR models, the model with w= 0.2, d=1 and k=0.5 performs best.
- All models are inaccurate for forecasts 16 through 22 weeks ahead. This can be attributed to the fluctuations in the interest rate from March to May 2002 (from 5.37 per cent to 7.22 per cent).

Thus, for 1-year government securities, BVAR models out-perform the alternatives at the short and long end.

Government Securities – 5-year (Tables 5D and 6D, Figures 1.1D-1.3D, 2.1D-2.3D, 3.1D-3.3D and 4D)

- ARMA model is generally more accurate than ARMA-GARCH. Accuracy of both models improves relative to the random walk for forecast horizons over 24 weeks.
- All models are inaccurate for forecasts 17 through 23 weeks ahead, which can be attributed to fluctuations in the interest rate from 6.43 per cent to 7.29 per cent.
- LVAR and BVAR models produce inaccurate forecasts, generally worse than those from a random walk.

- VECM yields the most accurate forecasts and is almost consistently better than the random walk.
- ARMA-ARCH model is more accurate than LVAR and the BVAR models.
- The poor performance of all the models with the exception of VECM is highlighted in Figure 4D.

For 5-year government securities, the BVAR models do not perform well. Overall, VECM outperforms all the alternative models. VECM also generally outperforms the alternatives at the short and long forecast horizons.

Government Securities – 10- year (Tables 5E and 6E, Figures 1.1E-1.3E, 2.1E-2.3E, 3.1E-3.3E and 4E)

- Introducing ARCH effects in the ARMA model does not improve forecast accuracy.
- LVAR produces the most accurate short-term and long-term forecasts, better than all other models.
- VECM is generally out-performed by LVAR and BVAR models.
- Performance of all BVAR models is reasonable and generally improves on loosening the prior. In the extreme case, with a very loose prior, the BVAR model converges to LVAR, which in this case is the preferred model.
- All models consistently out-perform the random walk.
- The accuracy of all the univariate models deteriorates with the increase in theforecast horizons (Table 6E).
- LVAR and BVAR models generally show improvement in accuracy with the increase in the forecast horizons (Table 6E).
- Figures 2E, 3E, and 4E reinforce the superiority of LVAR and BVAR models.

Therefore, for 10-year government securities, forecasting performance of all the models is satisfactory. The model that produces the most accurate forecasts is LVAR, or, in other words, a BVAR with a very loose prior. LVAR model produces the most accurate short- and long-term forecasts.

Thus, generally, BVAR models perform well and are able to beat the naïve forecast most of the time.

In the multivariate analysis above, the Bank Rate is used to capture the effect of monetary policy. Other variables included are: inflation, liquidity, credit, spread, Libor 3 and 6-months, forward premia 3 and 6-months. In the above models, we now examine, if the repo rate can be used in place of the Bank Rate, i.e., if the repo rate is a better predictor of interest rates compared to the Bank Rate. Tables 7A-7E report the out-of-sample forecast accuracy (reflected in a decrease in U) for both these rates as measured by the Theil statistic. The tables show that the improvement (if any) in accuracy from using the repo rate is marginal at best. The maximum improvement occurs in the TB 15-91 and that too by less than 10%. The Bank Rate can therefore be used as a satisfactory indicator of monetary policy.

SECTION V
CONCLUSIONS

This study discusses different models to forecast both short and long-term interest rates. Future movements in interest rates are critical to the financial decisions of businesses and households. Forecasting the behaviour of interest rates thus helps to reduce the risk associated with large fluctuations in the interest rates. Forecasting any economic variable can be a difficult task since the forecasts will depend on the model used to generate them. Hence it is important to study the properties of forecasts generated from different models and select the "best" on the basis of an objective criterion.

This study also highlights the differences between modelling short and long-term interest rates. This is reflected in the choice of variables in the multivariate models.

The conclusions for each interest rate are as follows:

- For the call money rate, an ARMA-GARCH model is best suited for very short-term forecasting while a BVAR model with a loose prior can be used for longer-term forecasting.
- For the 15-91 day Treasury Bill rate, the LVAR models produce the most accurate short and long-term forecasts.
- For 1-year government securities, BVAR models out-perform the alternatives at the short and long ends.
- For 5-year government securities, the BVAR models do not perform well. Overall, VECM outperforms all the alternative models. VECM also generally outperforms the alternatives at the short and long forecast horizons.
- For 10-year government securities, forecasting performance of all the models is satisfactory. The model that produces the most

accurate forecasts is LVAR, or, in other words, a BVAR with a very loose prior. LVAR model produces the most accurate short and long-term forecasts.

The selected models conform to expectations. Standard ARIMA models are based on a constant residual variance. Since financial time series are known to exhibit volatility clustering, this effect is taken into account by estimating ARCH/GARCH models. It is found that although the ARCH/GARCH effects are significant, the ARCH model produces more accurate out-of-sample forecasts relative to the corresponding ARIMA model only in the case of call money rate. This result is not surprising since the out-of sample period over which the alternative models are evaluated is relatively stable with no marked swing in the interest rates.

It is also found that the multivariate models generally produce more accurate forecasts over longer forecast horizons. This is because interactions and dependencies between variables become stronger for longer horizons. In other words, for short forecast horizons, predictions that depend solely on the past history of a variable may yield satisfactory results. This difference between univariate and multivariate models is illustrated in figures 3A-3E with respect to different forecast horizons. The advantage of using multivariate models is also highlighted in figures 4A-4E that depict forecasts made by a real time forecaster at a given point in time.

In the class of multivariate models, the Bayesian model generally outperforms its contenders. Unlike the VAR models, the Bayesian models are not adversely affected by degree of freedom constraints and overparameteiztion. In two cases, i.e., for TB 15-91 and GSec 10, the level VAR performs best suggesting that a loose prior is more appropriate for these models. Notice that with a loose prior, the Bayesian model approaches the VAR model with limited restrictions on the coefficients.

The VECM model outperforms the others only in the case of the GSec 5-years rate. Although inclusion of an error correction term in a VAR is generally expected to improve forecasting performance if the variables are indeed cointegrated, this contention did not find support in this study. This may be because cointegration is a long run phenomenon and the span of the estimation period in this study is not sufficiently large to permit a rigorous analysis of the long-run relationships. Thus, it is not surprising that the VAR models generally outperform the corresponding VECM forecasts.

Thus, to sum up, the forecasting performance of BVAR models for interest rates is satisfactory. The BVAR models generally produce more accurate forecasts compared to the alternatives discussed in the study and their superiority in performance is marked at longer forecast horizons. The variables included in the BVAR models are: inflation, Bank Rate, liquidity, credit, spread, Libor 3 and 6-months and forward premia 3 and 6-months. These variables are selected from a large set of potential series including the repo rate, Cash Reserve Ratio, foreign exchange reserves, exchange rate, stock prices, Ways and Means Advances (by RBI to Centre and State Governments), turnover (total turnover of all maturities), 3 and 6-months US Treasury Bill rate (secondary market), reserve money and its growth rates.

A closing remark on one caveat on the research method used in the Study. BVAR forecasts have one important limitation. The search for an optimal prior requires an objective function (i.e., the Theil U-statistic) that is optimized over the out-of-sample forecasts. The chosen prior, therefore, may not be optimal beyond the period for which it was selected. This shortcoming is not limited to BVAR models; it is a problem for all models selected on the basis of out-of-sample forecasts. In other words, the selected specification may not produce the 'best' forecasts outside the sample for which the selection was made.

REFERENCES

Ang, A. and Bekaert (1998), "Regime Switches in Interest Rates", *NBER Working Paper*, No. 6508.

Artis, Michael J. and W. Zhang (1990), "BVAR Forecasts for the G7", *International Journal of Forecastin*g, 6, 349-62

Barkoulas, J.T. and C.F. Baum (1997), "Fractional Differencing Modeling and Forecasting of Eurocurrency Deposit Rates", *Journal of Financial Research*, 20, 355-72.

Bhoi, B.K. and S. C. Dhal (1998), "Integration of Financial Markets in India: An Empirical Evaluation", *RBI Occasional Papers*, Vol.19, No.4, December.

Bidarkota, P. V. (1998), "The Comparative Performance of Univariate and Multivariate Models: An Application to Real Interest Rate Forecasting", *International Journal of Forecasting*, 14, 457-468.

Blejer, M.I. and J.G. Diaz (1986), " Domestic and External Factors in the Determination of the Real Interest Rate: The case of Uruguay", *Economic Develpoment and Cultural Change*, 589-606.

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroscedasticity", *Journal of Econometrics*, 31, 307-27.

Campbell, J. Y. and P. Perron (1991), "Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Root", *Technical Working Paper 100, NBER Working Paper Series*, April.

Campbell, J.Y. and R.J. Shiller (1991), "Yield Spreads and Interest Rate Movements: A Bird's Eye View", *Review of Economic Studies*, 58, 495-514.

Chiang, T.C. and D.R. Kahl (1991), "Forecasting the Treasury Bill Rate: A Time Varying Coefficient Approach", *Journal of Financial Research*, 14, 327-336.

Cole, S.C. and W. Reichenstein (1994), "Forecasting Interest Rates with Eurodollar Futures Rates", *Journal of Futures Markets*, 14, 37-50.

Cooley, T.F. and S.F. LeRoy (1985), "Atheoretical Macroeconometrics: A Critique", *Journal of Monetary Economics*, 16, 283-308.

Craine, R. and A. Havenner (1988), "Forecast Comparisons of Four Models of U.S. Interest Rates", *Journal of Forecasting*, 7, 21-29.

Deaves, R. (1996), "Forecasting Canadian Short-Term Interest Rates", *Canadian Journal of Economics*, 29, 615-634.

Dickey, David and Wayne A. Fuller (1979), "Distribution of the Estimates for Autoregressive Time Series with a Unit Root", *Journal of American Statistical Association*, 74, 427-31.

________ (1981), "Likelihood Ratio Statistics for Autoregressive Time Series Models: Tests and Implication", *Econometrica*, 49, 1057-72.

Doan, T. A. (1992), *RATS User's Manual*, III, Estima.

Doan, T. A., R.B. Litterman, and C. Sims,. (1984), "Forecasting and Conditional Projection Using Realistic Prior Distributions", *Econometric Reviews*, 3, 1-100.

Doldado, J., T. Jenkinson, and S. Sosvilla-Rivero (1990), "Cointegration and Unit Roots", *Journal of Economic Surveys*, 4, 249-73.

Dua, P. (1988), "Multiperiod Forecasts of Interest Rates", *Journal of Business and Economic Statistics*, 6, 381-384.

Dua, P. and S.M. Miller (1996), “Forecasting Connecticut Home Sales in a BVAR Framework Using Coincident and Leading Indexes”, *Journal of Real Estate Finance and Economics,* 13, 219-235.

Dua, P., S.M. Miller and D.J. Smyth (1999), “Using Leading Indicators to Forecast U.S. 7Home Sales in a Bayesian Vector Autoregressive Framework”, *Journal of Real Estate Finance and Economics,* 18, 191-205.

Dua, P. and B.L. Pandit (2002), “Interest Rate Determination in India: Domestic and External Factors”, *Journal of Policy Modeling,* 24, 853-875.

Dua, P. and S.C. Ray (1995), “A BVAR Model for the Connecticut Economy”, *Journal of Forecasting*, 14, 217-227.

Dua, P. and Smyth, D.J. (1995), “Forecasting U.S. Home Sales Using BVAR Models and Survey Data on Households’ Buying Attitudes for Homes”, *Journal of Forecasting,* 14, 167-180.

Edwards, S. and M. S. Khan (1985), “ Interest Rate Determination in Developing Countries: A Conceptual Framework”, *IMF Staff Papers*, 32, 377-403.

Engle, R.F. (1982), “Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation”, *Econometrica*, 50, 987-1007.

Engle, R. E. and C. W. J. Granger (1987), “Cointegration and Error Correction: Representation, Estimation and Testing”, *Econometrica*, 55, 251-76.

Fauvel, Y., A. Paquet, and C. Zimmermann,(1999), “A Survey on Interest Rate Forecasting”, Center for Research on Economic Fluctuations and Employment, Working Paper No. 87.

Froot, K.A. (1989), “New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates”, *Journal of Finance*, 44, 283-305.

Gochoco, M.S. (1991) “Financial Liberalisation and Interest Rate Determination: The case of Phillipines 1981-1985”, *Journal of Macroeconomics*, Spring 1991, 13, 2, 335-350.

Gosnell, T. F. (1997), “Accuracy of International Interest Rate Forecasts”, *Financial Review*, 32, 431-448.

Granger, C. W. J. (1986) “Developments in the Study of Co-integrated Economic Variables”, *Oxford Bulletin of Economics and Statistics*, 48, 213-228.

Granger, C. W. J. (1988) “Some Recent Developments in the Concept of Causality”, *Journal of Econometrics*, 39, 199-212.

Granger, C.W.J. and P. Newbold (1974), “Spurious Regressions in Econometrics”, *Journal of Econometrics*, 2, 111-20.

Gray, S. (1996), “Modelling the Conditional Distribution of Interest Rates as a Regime Switching Process”, *Journal of Financial Economics*, 42, 27-62.

Hafer, R.W., S.E. Hein, and S.S. MacDonald (1992), “Market and Survey Forecasts of the Three-Month Treasury-Bill Rate”, *Journal of Business*, 65, 123-138.

Hakkio, C.S. and M. Rush, (1991), “Cointegration: How Short is the Long-Run?” *Journal of International Money and Finance*, 10, 571-581.

Holden, K. and J.L. Thompson (1996), “Forecasting Interest Rates from Financial Futures Markets”, *Applied Financial Economics*, 6, 449-461.

Holden, K. and A. Broomhead, (1990), “An Examination of Vector Autoregressive Forecasts for the U.K. Economy”, *International Journal of Forecasting*, 6, 11-23.

Iyer, S. and R.L. Andrews (1999), “Forecasting with Latent Structure Time Series Models: An Application to Nominal Interest Rates”, *Journal of Forecasting*, 18, 395-409.

Johansen, S. and Katerina Juselius, (1990), “Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money”, *Oxford Bulletin of Economics and Statistics*, 52, 169-209.

_____________ (1992), “Testing Structural Hypothesis in a Multivariate Cointegartion Analysis of PPP and the UIP for UK”, *Journal of Econometrics*, 53, 211-44.

Jondeau, E. and F. Sedillot (1999), “Forecasting French and German Long-Term Rates Using a Rational Expectations Model”, *Weltwirtschaftliches Archiv*, 135, 413-436.

Jorion, P. and Frederic Mishkin (1991), “A Multicountry Comparison of Term-Structure Forecasts at Long Horizons”, *Journal of Financial Economics*, 29, 59-80.

Kolb, R.A. and H.O. Stekler (1996), “How Well Do Analysts Forecast Interest Rates?”, *Journal of Forecasting*, 15, 385-94.

Kwiatkowski, Denis, Peter C.B. Phillips, Peter Schmidt, and Yongcheol Shin (1992), “Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root”, *Journal of Econometrics*, 54, 159-178.

Litterman, R. (1981), “A Bayesian Procedure for Forecasting with Vector Autoregressions”, Federal Reserve Bank of Minneapolis, Working Paper.

__________ (1986), "Forecasting with Bayesian Vector Autoregressions – Five Years Experience", *Journal of Business and Economic Statistics,* 4, 25-38.

Mishkin, F.S. (1989), "The Information in the Longer Maturity Term Structure about Future Inflation", *NBER Working Paper No. 3126.*

Park, T.H. and L.N. Switzer (1997), "Forecasting Interest Rates and Yield Spreads: The Informational Content of Implied Futures Yields and Best-Fitting Forward Rate Models", *Journal of Forecasting,* 16, 209-24.

Perron, P. (1989), "Testing for a Random Walk: A Simulation Experiment of Power when the Sampling Interval is Varied", in B. Raj, ed., *Advances in Econometrics and Modeling,* Kluwer Academic Publisher.

Pesando, J.E. (1981), "On Forecasting Interest Rates: An Efficient Markets Perspective," *Journal of Monetary Economics,* 8, 305-318.

Phillips, P. and P. Perron (1988), "Testing for a Unit Root in Time Series Regression", *Biometrica*, 75, 335-46.

Prell, M.J. (1973), "How Well Do the Experts Forecast Interest Rates?" *Federal Reserve Bank of Kansas City Monthly Revie*w, September-October, 3-13.

Reserve Bank of India (1998), Report of the Working Group on Money Supply: Analytics and Methodology of Compilation. (Chairman: Dr. Y. V. Reddy).

Roley, V.V. (1982), "Forecasting Interest Rates with a Structural Model", *Journal of Portfolio Management* 8, 53-63.

Sarantis, N. and S.X. Lin (1999), "The Role of Financial Spreads in Macroeconomic Forecasting: Evidence for the UK", *Manchester School,* 67, 89-110.

Sen Gupta, Indranil, I. Bhattacharyya, Satyananda Sahoo and Siddhartha Sanyal (2000), "Anatomy of Liquidity Management", *RBI Occasional Papers*, 21(2 & 3), 291-321.

Shiller, R.J. and P. Perron (1985), "Testing the Random Walk Hypothesis: Power versus Frequency of Observation", *Economics Letters*, 18, 381-86.

Sims, C.A. (1980), "Macroeconomics and Reality", *Econometrica,* 48, 1-48.

Sims, C.A., J. Stock and M.W. Watson (1990), "Inference in Linear Time Series Models with Some Unit Roots", *Econometrica*, 58, 113-144.

Sola, M. and J. Driffill (1994), "Testing the Term Structure of Interest Rates Using a Stationary Vector Autoregression with Regime Switching", *Journal of Economic Dynamics and Control,* 18, 601-628.

Spencer, D.E. (1993), "Developing a Bayesian Vector Autoregression Forecasting Model", International Journal of Forecasting, 9, 407-421.

Theil, Henri (1966), *Applied Economic Forecasting,* Amsterdam, North Holland.

__________ (1971), *Principles of Econometrics,* John Wiley and Sons, New York, and North-Holland Publishing Company, Amsterdam.

Throop, A.W. (1981), "Interest Rate Forecasts and Market Efficiency", Federal Reserve Bank of San Francisco Working Paper, 29-43.

Todd, R.M. (1984), "Improving Economic Forecasting with Bayesian Vector Autoregression", Quarterly Review, Federal Reserve Bank of Minneapolis, Fall, 18-29.

Zellner, A. (1979), "Statistical Analysis of Econometric Models", *Journal of the American Statistical Association,* 74, 628-643.

Zellner, A. and F. Palm, (1974), "Time Series Analysis and Simultaneous Equation Econometric Models", *Journal of Econometrics,* 2, 17-54.

ANNEXURE I

Chronology of Reform Measures in Respect of Monetary Policy

1991-92

Discontinuation of sector-specific and programme specific prescriptions excepting for a few areas like; agriculture, small industries, the Differential Rate of Interest (DRI) scheme and export credit.

Deposit rates and interest stipulations were simplified by reducing the number of slabs.

Phased reduction in Statutory Liquidity Ratio (SLR).

1992-93

Simplification of ceilings on deposit rates. The existing maturity-wise prescriptions were replaced by a single ceiling rate of 13 per cent on all deposits above 46 days.

Cash Reserve Ratio (CRR) reduced from 15.0 per cent to 14.5 per cent.

1993-94

New Foreign Currency (Non-Resident) Deposits (Banks) [FCNR(B)] Scheme was introduced. Under this scheme exchange risk has to be borne by the banks and interest rates prescribed by RBI. The earlier scheme Foreign Currency Non-Resident Accounts [FCNR(A)] was phased out and closed by August 1994.

Banks were permitted to issue Certificate of Deposits (CDs).

Definition of priority sector was enlarged.

1994-95

Minimum lending rate for loans over Rs.2 lakh was no longer prescribed and the banks were allowed to fix Prime Lending Rate (PLR) for advances over Rs.2 lakh.

Cooperative banks' lending rates were freed.

CRR increased from 14.5 per cent to 15.0 per cent.

Incremental SLR was reduced to 25 per cent. Base level SLR reduced to 33.75 per cent.

Co-operative banks' deposit rates were freed.

1995-96

CRR was reduced from 15.0 per cent to 14.0 per cent.

Banks were given freedom to fix their own interest rates on domestic and Non-Resident Indian (NRI) deposits with maturity of over two years.

1996-97

Banks were given freedom to fix deposit rates for term deposits above one year maturity.

CRR was reduced from 14.0 per cent to 10.0 per cent.

Inter bank liabilities were exempted from CRR.

1997-98

Bank Rate was reinstated as the signaling rate linked to all other rates charged on Reserve Bank accommodation effective April 16, 1997 empowering the refinance facility to act as a potential liquidity adjustment mechanism. The reactivation of the Bank Rate also began serving as a reference rate for the entire financial system and together with repo rate, defined the corridor for money market rates.

Interest rates on bank deposits of less than one year were linked to Bank Rate (Bank Rate less 200 basis points).

Ceilings on loans below Rs.25,000 were fixed at PLR of the respective banks.

Banks were given full freedom to determine interest rates on term deposits of 30 days and above.

The entire structure of lending rates was deregulated and banks were given the freedom to offer fixed/floating PLR on loans of all maturities including small loans upto Rs.2.0 lakhs. Prescriptions by Reserve Bank were confined to interest rates for export credit and DRI advances. Banks were given freedom to fix their own service charges and all money market rates were freed.

Interest rates on foreign currency deposits were to be determined by banks subject to ceiling rate prescribed by RBI; these rates were subsequently linked to LIBOR.

Supplemental Agreement reached between the Government and the Reserve Bank resulted in complete phasing out of *ad hoc* Treasury Bills effective April 1, 1997.

SLR was brought down to 25 per cent effective October 25, 1997.

1998-99

Banks were given freedom to offer differential rate of interest based on size of deposits.

Minimum period of maturity of term deposits reduced to 15 days from 30 days.

Banks were advised to determine their own penal rates of interest on premature withdrawal of domestic term deposits and NRE deposits.

Banks were allowed to charge interest rate on loans against fixed deposits not exceeding its PLR.

Banks were provided freedom to operate tenor-linked PLR i.e., PLR for different maturities.

1999-2000

The Interim Liquidity Adjustment Facility (ILAF) was introduced in April 1999. The ILAF was a precursor to the present day Liquidity Adjustment Facility (LAF). The ILAF provided a mechanism for liquidity management through a combination of repos, export credit refinance and collateralized lending facilities (CLF) supported by open market operations at set rates of interest.

Banks were allowed to offer loans on fixed or floating rate basis provided PLR stipulations were adhered to.

Floor rate on Export Bills was withdrawn.

Savings deposit rates were reduced from 4.5 per cent to 4.0 per cent.

CRR was reduced from 10.0 per cent to 9.0 per cent.

2000-01

After gauging the success at the ILAF, a full-fledged LAF was initiated on June 5, 2000. Repo/reserve repo auctions were conducted on a daily basis except Saturdays, with a tenor of one day except on Fridays and days preceding the holidays. Interest rate in respect of both repos and reverse repos were decided through cut-off rates emerging from auctions conducted by the Reserve Bank on uniform price basis. In August 2000, repo auctions of tenors ranging between 3 to 7 days were introduced.

Banks were allowed to lend at sub-PLR rates.

CRR was reduced from 9.0 per cent to 8.0 per cent.

Bank Rate was reduced from 8.0 per cent to 7.0 per cent.

2001-02

In the gradual switchover to the subsequent stage of LAF, the total quantum of support available to banks under CLF and export credit refinance and the quantum of support available for Primary Dealers (PDs), was split into two components, *i.e.* 'normal facility' for the two-third of the total quantum of support and the 'backstop facility' for one third of the total quantum of support, effective May 5, 2001.

Effective May 8, 2001, LAF operating procedures further changed as follows: a) minimum bid size for LAF reduced to Rs. 5 crore from the existing Rs.10 crore; b) option to switch over to fixed rate repos on overnight basis as and when felt necessary; c) discretion to introduce longer-term repos upto 14 days; d) LAF auction timing advanced by 30 minutes and results by 12 noon; e) data on Scheduled Commercial Banks aggregate cumulative cash balances during the fortnight to be disseminated with a lag of two days; and f) multiple price auctions (in place of existing uniform price auction) to be introduced on an experimental basis during May 2001).

CRR was reduced from 8.0 per cent to 5.5 per cent.

Bank Rate was reduced from 7.0 per cent to 6.5 per cent.

Repo rate was reduced from 7.0 per cent to 6.0 per cent.

2002-03

The interest rate on savings account offered by banks was reduced to 3.5 per cent per annum from 4.0 per cent annum with effect from March 1, 2003.

The benchmark PLR continued to be the ceiling rate for credit limit up to Rs.2 lakh. The system of determination of benchmark PLR by banks and the actual prevailing spreads around the benchmark PLR would be reviewed in September 2003.

CRR was reduced from 5.5 per cent to 4.75 per cent.

Bank Rate was reduced from 6.5 per cent to 6.25 per cent.

Repo rate was reduced from 6.0 per cent to 5.0 per cent.

ANNEXURE II

DATA DEFINITIONS AND SOURCES

Both univariate and multivariate forecasting have been carried out using a common sample from April 1997 to September 2002. The data definitions and sources of the variables are given in the Table below :

Variable	Definition	Source
CALL	Weekly weighted average call money rates as compiled by the Reserve Bank. The call money rate upto 1997-98 is the weighted arithmetic average of the rate at which money was accepted and reported by select scheduled commercial banks at Mumbai, the weights being proportional to the amounts accepted during the period by respective banks. Data for the period 1998-99 till April 2001 relate to those reported by scheduled commercial banks, primary dealers and select financial institutions. Data since May 2001 include those of commercial banks, primary dealers, financial institutions, insurance companies and mutual funds.	Handbook of Statistics on the Indian Economy and RBI Bulletin

Variable	Definition	Source
TB 15-91	Government of India Treasury Bills of residual maturity of 15-91 days based on the secondary market outright transactions in Government securities (face value) as reported in Subsidiary Government Ledger (SGL) accounts at RBI, Mumbai.	Handbook of Statistics on the Indian Economy and RBI Bulletin
GSEC1	Government of India dated securities of residual maturity of one year based on the secondary market outright transactions in Government securities (face value) as reported in Subsidiary Government Ledger (SGL) accounts at RBI, Mumbai.	Handbook of Statistics on the Indian Economy and RBI Bulletin
GSEC5	Government of India dated securities of residual maturity of five years based on the secondary market outright transactions in Government securities (face value) as reported in Subsidiary Government Ledger (SGL) accounts at RBI, Mumbai.	Handbook of Statistics on the Indian Economy and RBI Bulletin
GSEC10	Government of India dated securities of residual maturity of ten years and above based on the secondary market outright transactions in Government securities (face value) as reported in Subsidiary Government Ledger (SGL) accounts at RBI, Mumbai.	Handbook of Statistics on the Indian Economy and RBI Bulletin

Variable	Definition	Source
LIBOR 3-months	Three-month LIBOR on USD deposits	Moneyline TeleRate
LIBOR 6-months	Six-month LIBOR on USD deposits	Moneyline TeleRate
Bank Rate	Bank Rate	Handbook of Statistics on the Indian Economy
REPO	Repo rate	See Note (1)
FP 3-months	Three-month forward premium	Handbook of Statistics on the Indian Economy and Weekly Statistical Supplement
FP 6-months	Six-month forward premium	Handbook of Statistics on the Indian Economy and Weekly Statistical Supplement
LIQUIDITY	Liquidity indicator variable	See Note (2)
CREDIT	Total credit (Food and Non-food). Data on food and non-food credit are available on a fortnightly basis. The weekly data are generated taking the average of the previous fortnight and succeeding fortnight figures.	Weekly Statistical Supplement

Variable	Definition	Source
INFLATION	Both week-to-week and year-on-year inflation rate have been used.	Weekly Statistical Supplement
SPREAD	10-Year government security rate *minus* 91- days Treasury Bills rate.	As above

Note:

(1) Repo Rate

Repo rates for the period November 29, 1997 to June 5, 2000 are fixed rate repos. These rates are the cut-off rates based on the auctions made by the Reserve Bank. The fixed rate repo system was replaced by the introduction of the Liquidity Adjustment Facility (LAF) with effect from June 5, 2000 that operates with auction based repo (absorption) and reverse repo (injection) system. Whenever the repo (absorption) is non-existent, the rate has been calculated by taking the average of the previous day repo (absorption) rate and current reverse repo (injection) rate.

(2) Estimation of the LIQUIDITY Variable

The LIQUIDITY variable, as an indicator of market liquidity is estimated from bank reserves. Most of the recent research use bank reserves as a proxy for market liquidity. Bank reserves are the sum of reserve requirements and settlement balances including excess reserves. In economies where reserve requirements are marginal, bank reserves directly reflect the demand for settlement balances and excess reserves. In the Indian case, although reserve requirements continue to be significant, data on required reserves is not published. Hence, the study uses total reserves rather than excess reserves. Besides, in view of frequent cash reserve ratio (CRR) changes, there was a need to adjust bank reserves for changes in reserve requirements (see Sen Gupta *et. al.* (2000)).

The demand for bank reserves is expected to affect the lower end of the maturity spectrum of interest rates in the first round.

(3) Forward Premium

Given the gradual integration between the foreign exchange market and the domestic money market, the forward premium is expected to be an explanatory variable in the determination of domestic interest rates (Bhoi and Dhal, 1998).

(4) Yield Spread

The yield spread is defined as the difference between the Government of India dated securities on residual maturity of ten-years and above and the 91-days treasury bills rate. It may be mentioned that the empirical models reported in this study use the Government of India Treasury Bills on residual maturity of 15-91 days based on the secondary market outright transactions in Government securities (face value). Since data on exact 91-days are not available for the secondary market instruments, the 91-days treasury bills rate (primary market) has been used while calculating the yield spread.

Table 1.1A

Unit Root Tests: Interest Rates

(4th April 1997 to 27th Sep 2002)

TESTS VARIABLE	Null: γ=0 in Eq. (3) τ_τ	Null: γ=0, α=0 in Eq. (3) ϕ_1	Null: γ=0 in Eq.(2) τ_μ	Null: γ=0, α=0 in Eq.(2) ϕ_1	Null:γ=0 Eq. (1) τ	RESULTS (UNIT ROOT PRESENT)
ADF Test Call	–2.7811	5.4754	–2.8663	4.1488	–0.1408	Yes
PP – Test Call	-6.8731					No
ADF Test TB 15-91	–2.7826	4.8078	–2.1482	2.3083	–0.3675	Yes
PP – Test TB 15-91	–5.0258					No
ADF Test GSec 1	–-1.4013	1.7811	–0.1033	0.7163	–1.1964	Yes
PP – Test GSec 1	–2.5803	3.4403	–1.5296	1.5194	–1.0830	Yes
ADF Test GSec 5	–1.4301	1.3449	0.0149	2.1185	–2.0284	Yes
PP – Test GSec 5	–2.0582	2.2371	–0.5675	1.6432	–1.7982	Yes
ADF Test GSec 10	–1.0165	1.9433	0.9373	2.4971	–1.8928	Yes
PP – Test GSec 10	–2.4080	3.1000	–0.6252	1.1396	–1.4511	Yes
Critical Values						
10%	-3.13	5.34	-2.57	3.78	-1.62	
5%	-3.41	6.25	-2.86	4.59	-1.95	
1%	-3.96	8.27	-3.43	6.43	-2.58	

Table 1.1B

Unit Root Tests: Variables in Multivariate Models
(4Th April 1997 to 27th Sep 2002)

TESTS VARIABLE	Null: γ=0 in Eq. (3) τ_τ	Null: γ=0, α=0 in Eq. (3) ϕ_1	Null: γ=0 in Eq.(2) τ_μ	Null: γ=0, α=0 in Eq. (3) ϕ_1	Null:γ=0 Eq. (1) τ	RESULTS (UNIT ROOT PRESENT)
ADF Test FP-3months	–2.8823	4.4100	–2.1868	2.3929	–0.6641	Yes
PP – Test FP-3months	–4.1844					No
ADF Test FP-6months	–2.5820	3.6693	–1.7450	1.5229	–0.5247	Yes
PP – Test FP-6months	–3.4559	5.9741	–3.1015	4.8300	–1.2992	Yes
ADF Test Inflation (year-on-year)	–1.6866	1.4224	–1.6486	1.4480	–0.9981	Yes
PP – Test Inflation (year-on-year)	–1.7583	1.5472	–1.7184	1.5590	–1.0072	Yes
ADF Test LIBOR-3months	–1.6423	1.7114	–0.7667	0.6723	–1.0520	Yes
PP – Test LIBOR-3months	–0.4825	2.9814	1.2195	3.7826	–1.9507	Yes
ADF Test LIBOR-6months	–1.5795	1.7062	–0.6489	0.6280	–1.0605	Yes
PP – Test LIBOR-6months	–0.3411	3.0851	1.3736	4.4630	–2.0811	Yes
ADF Test Bank Rate	–3.2039	5.3812	–1.5325	2.8072	–2.0119	Yes

(contd....)

Table 1.1B *(Concluded)*

Unit Root Tests: Variables in Multivariate Models (4Th April 1997 to 27th Sep 2002)

TESTS VARIABLE	Null: γ=0 in Eq. (3) τ_τ	Null: γ=0, α=0 in Eq. (3) ϕ_1	Null: γ=0 in Eq.(2) τ_μ	Null: γ=0, α=0 in Eq. (3) ϕ_1	Null:γ=0 Eq. (1) τ	RESULTS (UNIT ROOT PRESENT)
PP – Test Bank Rate	–4.5168					No
ADF Test Repo Rate	–2.7577	4.2585	-2.9242	4.3125	–0.3141	Yes
PP – Test Repo Rate	–3.3344	5.6361	–3.3113	5.4851	–0.7729	Yes
ADF Test Spread	–2.1485	2.8604	–2.0077	3.0540	–2.0818	Yes
PP – Test Spread	–3.4821	6.1687	–2.2768	2.8958	–1.6155	Yes
ADF Test Inflation (week-to-week)	–6.7507					No
PP – Test Inflation (week-to-week)	–15.538					No
ADF Test Credit	–1.2590	2.3677	1.5198	5.1700	3.2130	Yes
PP – Test Credit	–1.4108	3.9202	2.1503	19.0300		Yes
ADF Test Liquidity	–2.3712	5.4351	2.0295	19.4790		Yes
PP – Test Liquidity	–21.2670					No
Critical Values						
10%	-3.13	5.34	-2.57	3.78	-1.62	
5%	-3.41	6.25	-2.86	4.59	-1.95	
1%	-3.96	8.27	-3.43	6.43	-2.58	

Table 1.2

KPSS Level Stationarity Test

	l=0	l=1	l=2	L=3	l=4	l=5	l=6	l=7	l=8	Conclusion (Unit Root Present)
Call	3.0161	1.7590	1.2842	1.0434	0.8908	0.7831	0.6996	0.6345	0.5812	Yes
TB 15-91	4.0575	2.1826	1.5559	1.2335	1.0320	0.8933	0.7912	0.7139	0.6538	Yes
GSec 1	15.9503	8.1296	5.4985	4.1773	3.3822	2.8516	2.4730	2.1891	1.9680	Yes
GSec 5	22.8168	11.5259	7.7465	5.8517	4.7119	3.9504	3.4058	2.9975	2.6801	Yes
GSec 10	22.1516	11.2160	7.5453	5.7062	4.6007	3.8626	3.3348	2.9388	2.6306	Yes
fp-3months	4.8488	2.5593	1.7775	1.3868	1.1475	0.9868	0.8726	0.7880	0.7229	Yes
fp-6months	7.4406	3.8533	2.6377	2.0287	1.6588	1.4109	1.2343	1.1025	1.0002	Yes
Inflation (year-on-year)	2.9759	1.5036	1.0113	0.7652	0.6178	0.5198	0.4500	0.3979	0.3574	Yes
LIBOR-3months	14.8076	7.4365	4.9756	3.7448	3.0064	2.5143	2.1630	1.8998	1.6952	Yes
LIBOR-6months	14.8824	7.4763	5.0032	3.7661	3.0240	2.5295	2.1765	1.9120	1.7064	Yes
Bank Rate	24.2326	12.3041	8.2889	6.2748	5.0648	4.2580	3.6820	3.2505	2.9153	Yes
Repo	3.7406	1.9419	1.3334	1.0289	0.8470	0.7260	0.6391	0.5737	0.5229	Yes
Spread	20.4757	10.4332	7.0479	5.3517	4.3317	3.6499	3.1626	2.7970	2.5121	Yes
Inflation (week-to-week)	0.1138	0.1006	0.0915	0.0864	0.0812	0.0778	0.0770	0.0771	0.0781	No
Credit	27.8840	14.0262	9.3934	7.0747	5.6827	4.7546	4.0915	3.5943	3.2077	Yes
Liquidity	27.2143	14.1717	9.5184	7.1881	5.7725	4.8316	4.1563	3.6510	3.2567	Yes

Note: l is the lag truncation parameter.

Asymptotic critical values for $\hat{\eta}_\mu$:

Critical level:	0.10	0.05	0.025	0.01
Critival value($\hat{\eta}_\mu$):	0.347	0.463	0.574	0.739

Table 1.3

Unit Root Tests (Summary)

	ADF	**PP**	**KPSS**
Call	Yes	No	Yes
TB 15-91	Yes	No	Yes
Gsec 1	Yes	Yes	Yes
Gsec 5	Yes	Yes	Yes
Gsec 10	Yes	Yes	Yes
FP-3months	Yes	No	Yes
FP-6months	Yes	Yes	Yes
Inflation (year-on-year)	Yes	Yes	Yes
LIBOR-3months	Yes	Yes	Yes
LIBOR-6months	Yes	Yes	Yes
Bank Rate	Yes	No	Yes
Repo Rate	Yes	Yes	Yes
Spread	Yes	Yes	Yes
Inflation (week-to-week)	No	No	No
Credit	Yes	Yes	Yes
Liquidity	Yes	No	Yes

Univariate Models

Table 2A: Call Money Rate

ARMA (2,2)

$$\textbf{Call} = \underset{(0.649)}{0.005} - \underset{(0.000)}{0.435}\,Call_{t-1} + \underset{(0.000)}{0.545}\,Call_{t-2} + \varepsilon_t + \underset{(0.000)}{0.059}\,\varepsilon_{t-1} - \underset{(0.000)}{0.922}\,\varepsilon_{t-2}$$

AIC = 3.147 **SBC** = 3.219 **LL** = – 380.560

Q-Statistics: Q(8) = 5.761 (0.218) **Q(16) =** 18.990 (0.089) **Q(24) =** 28.223 (0.104)

ARCH-LM Test: $\chi^2(1)$ = 5.711 (0.017) $\chi^2(4)$ = 19.425 (0.001) $\chi^2(8)$ = 23.867 (0.002)

ARMA(2,2)–GARCH(1,1)

$$\textbf{Call} = \underset{(0.738)}{0.006} - \underset{(0.000)}{0.384}\,Call_{t-1} + \underset{(0.000)}{0.598}\,Call_{t-2} + \varepsilon_t + \underset{(0.124)}{0.088}\,e_{t-1} - \underset{(0.000)}{0.893}\,e_{t-2}$$

$$\mathbf{h_t} = \underset{(0.002)}{0.092} + \underset{(0.004)}{0.120}\,\varepsilon^2_{t-1} + \underset{(0.000)}{0.788}\,h_{t-1}$$

AIC = 2.932 **SBC** = 3.046 **LL** = – 351.174

Q-Statistics: Q(8) = 4.904 (0.297) **Q(16) =** 15.493 (0.216) **Q(24) =** 19.561 (0.486)

Table 2B: TB 15-91

ARMA (3,0)

$$\textbf{TB(15-91)} = \underset{(0.463)}{-0.019} \underset{(0.002)}{-0.216}\,TB(15\text{-}91)_{t-1} \underset{(0.341)}{-0.067}\,TB(15\text{-}91)_{t-2} \underset{(0.000)}{-0.259}\,TB(15\text{-}91)_{t-3} + \varepsilon_t$$

AIC = 1.658 **SBC** = 1.724 **LL** = – 160.966

Q-Statistics: Q(8) = 8.277 (0.142) **Q(16) =** 19.780 (0.101) **Q(24) =** 27.655 (0.150)

ARCH-LM Test: $\chi^2(1)$ = 0.771 (0.379) $\chi^2(4)$ = 1.696 (0.791) $\chi^2(8)$ = 2.915 (0.939)

ARMA(3,0)–ARCH(1)

$$\textbf{TB(15-91)} = \underset{(0.721)}{0.008} \underset{(0.031)}{-0.169}\,TB(15\text{-}91)_{t-1} \underset{(0.009)}{-0.133}\,TB(15\text{-}91)_{t-2} \underset{(0.000)}{-0.287}\,TB(15\text{-}91)_{t-3} + \varepsilon_t$$

$$\mathbf{h_t} = \underset{(0.000)}{0.187} + \underset{(0.001)}{0.517}\,\varepsilon^2_{t-1}$$

AIC = 1.609 **SBC** = 1.709 **LL** = – 154.159

Q-Statistics: Q(8) = 8.105 (0.151) **Q(16) =** 17.582 (0.174) **Q(24) =** 23.835 (0.301)

Table 2C: 1-year Government Securities

ARMA (1,0)

$$\mathbf{GSec1} = -0.029 - 0.206\, GSec1_{t-1} + \varepsilon_t$$
$$(0.138)\quad (0.005)$$

AIC = 0.571 **SBC** = 0.607 **LL** = – 49.72

Q-Statistics:	**Q(8) =** 10.684 (0.153)	**Q(16) =** 17.576 (0.286)	**Q(24) =** 25.432 (0.328)
ARCH-LM Test:	$\chi^2(1)$ = 10.949 (0.001)	$\chi^2(4)$ = 25.453 (0.000)	$\chi^2(8)$ = 29.860 (0.000)

ARMA(1,0)–GARCH(1,1)

$$\mathbf{GSec1} = -0.027 - 0.119\, GSec1_{t-1} + \varepsilon_t$$
$$(0.077)\quad (0.104)$$

$$\mathbf{h_t} = 0.004 + 0.103\, \varepsilon^2_{t-1} + 0.810\, h_{t-1}$$
$$(0.000)\quad (0.000)\quad (0.000)$$

AIC = 0.115 **SBC** = 0.203 **LL** = – 5.384

Q-Statistics:	**Q(8) =** 7.767 (0.354)	**Q(16) =** 13.644 (0.553)	**Q(24) =** 19.279 (0.685)

Table 2D: 5-year Government Securities

ARMA (2,0)

$$\mathbf{GSec5} = -0.020 + 0.100\, GSec5_{t-1} - 0.169\, GSec5_{t-2} + \varepsilon_t$$
$$(0.147)\quad (0.116)\quad (0.008)$$

AIC = – 0.072 **SBC** = – 0.029 **LL** = 11.772

Q-Statistics:	**Q(8) =** 10.779 (0.095)	**Q(16) =** 13.449 (0.492)	**Q(24) =** 19.291 (0.627)
ARCH-LM Test:	$\chi^2(1)$ = 52.119 (0.000)	$\chi^2(4)$ = 63.031 (0.000)	$\chi^2(8)$ = 67.524 (0.000)

ARMA(2,0)–ARCH(2,0)

$$\mathbf{GSec5} = -0.020 + 0.044\, GSec5_{t-1} - 0.007\, GSec5_{t-2} + \varepsilon_t$$
$$(0.029)\quad (0.571)\quad (0.895)$$

$$\mathbf{h_t} = 0.016 + 0.831\, \varepsilon^2_{t-1} + 0.134\, \varepsilon^2_{t-2}$$
$$(0.000)\quad (0.000)\quad (0.059)$$

AIC = – 0.480 **SBC** = – 0.395 **LL** = 64.847

Q-Statistics:	**Q(8) =** 3.427 (0.754)	**Q(16) =** 8.413 (0.867)	**Q(24) =** 15.230 (0.852)

<u>Table 2E: 10-year Government Securities</u>

ARMA (1,0)

GSec10 $= -0.017 - 0.076\ GSec10_{t-1} + \varepsilon_t$

(0.216) (0.239)

AIC = – 0.117 **SBC** = – 0.089 **LL** = 16.426

LB Q-Statistics:	**Q(8) =** 10.839	**Q(16) =** 21.019	**Q(24) =** 24.488
	(0.146)	(0.136)	(0.377)
ARCH-LM Test:	$\chi^2(1) = 0.012$	$\chi^2(4) = 3.584$	$\chi^2(8) = 3.723$
	(0.913)	(0.465)	(0.881)

ARMA(1,0)–ARCH(1,0)

GSec10 $= -0.015 - 0.112\ GSec10_{t-1} + \varepsilon_t$

(0.385) (0.230)

$\mathbf{h_t} = 0.048 + 0.074\ \varepsilon^2_{t-1}$

(0.000) (0.315)

AIC = – 0.108 **SBC** = – 0.051 **LL** = 17.241

LB Q-Statistics:	**Q(8) =** 10.807	**Q(16) =** 21.282	**Q(24) =** 24.943
	(0.147)	(0.128)	(0.353)

Note: p-value in parenthesis.

Table 3

Tests for Cointegration: λ_{max} Tests

H_0 :	H_1 :	Statistics	Critical values 99%	Critical values 95%	RESULTS	No. of C. V.
MODEL A : $i_{(Call)} = f(\pi_1$, **Bank Rate, Spread, Liquidity,** i^*_1, $fp_1)$						
r = 0	**r = 1**	79.32	45.10	39.37	Reject Null Hypothesis	1
r ≤ 1	**r = 2**	38.68	38.77	33.46	Do not Reject Null Hypothesis	
MODEL B : $i_{(TB\ 15\text{-}91)} = f(\pi_2$, **Bank Rate, Spread, Liquidity,** i^*_1, $fp_1)$						
r = 0	**r = 1**	59.12	51.57	45.28	Reject Null Hypothesis	1
r ≤ 1	**r = 2**	37.41	45.10	39.37	Do not Reject Null Hypothesis	
MODEL C : $i_{(GSec\ 1)} = f(\pi_2$, **Bank Rate, Spread, Liquidity,** i^*_2, $fp_2)$						
r = 0	**r = 1**	52.75	51.57	45.28	Reject Null Hypothesis	1
r ≤ 1	**r = 2**	40.13	45.10	39.37	Do not Reject Null Hypothesis	
MODEL D : $i_{(GSec\ 5)} = f(\pi_2$, **Bank Rate, Spread, Credit,** i^*_2, $fp_2)$						
r = 0	**r = 1**	55.29	51.57	45.28	Reject Null Hypothesis	1
r ≤ 1	**r = 2**	36.23	45.10	39.37	Do not Reject Null Hypothesis	
MODEL E : $i_{(GSec\ 10)} = f(\pi_2$, **Bank Rate, Spread, Credit,** i^*_2, $fp_2)$						
r = 0	**r = 1**	63.77	51.57	45.28	Reject Null Hypothesis	1
r ≤ 1	**r = 2**	40.68	45.10	39.37	Do not Reject Null Hypothesis	

Note: r is the order of cointegration. C. V. denotes the cointegrating vector. π_1 and π_2 denote inflation (week-to-week) and inflation (year-on-year), respectively. i^*_1 and i^*_2 denote LIBOR-3 months and LIBOR-6 months respectively. fp_1 and fp_2 denote three- and six-months Forward Premium, respectively. Critical values are from Osterwald M. and Lenum (1992).

Table 4

Granger Causality Tests

Null Hypothesis	Number of Lags	$\chi 2$ (calculated)	Conclusion
MODEL A : $i_{(Call)} = f(\pi_1^{\dagger}$, Bank Rate, Spread, Liquidity, i^*_1, $fp_1)$			
$i_{(Call)}$ is not granger caused by **Bank Rate**	3	70.99 (.00)	Reject null hypothesis*
$i_{(Call)}$ is not granger caused by **Spread**	3	52.42 (.00)	Reject null hypothesis*
$i_{(Call)}$ is not granger caused by **Liquidity**	3	43.66 (.00)	Reject null hypothesis*
$i_{(Call)}$ is not granger caused by i^*_1	3	44.11 (.00)	Reject null hypothesis*
$i_{(Call)}$ is not granger caused by fp_1	3	61.51 (.00)	Reject null hypothesis*
MODEL B : $i_{(TB\ 15\text{-}91)} = f(\pi_2$, Bank Rate, Spread, Liquidity, i^*_1, $fp_1)$			
$i_{(TB\ 15\text{-}91)}$ is not granger caused by π_2	2	54.94 (.00)	Reject null hypothesis*
$i_{(TB\ 15\text{-}91)}$ is not granger caused by **Bank Rate**	2	114.29 (.00)	Reject null hypothesis*
$i_{(TB\ 15\text{-}91)}$ is not granger caused by **Spread**	2	45.75 (.00)	Reject null hypothesis*
$i_{(TB\ 15\text{-}91)}$ is not granger caused by **Liquidity**	2	50.50 (.00)	Reject null hypothesis*
$i_{(TB\ 15\text{-}91)}$ is not granger caused by i^*_1	2	45.23 (.00)	Reject null hypothesis*
$i_{(TB15\text{-}91)}$ is not granger caused by fp_1	2	115.37 (.00)	Reject null hypothesis*
MODEL C : $i_{(GSec\ 1)} = f(\pi_2$, Bank Rate, Spread, Liquidity, i^*_2, $fp_2)$			
$i_{(GSEC\ 1)}$ is not granger caused by π_2	3	43.36 (.00)	Reject null hypothesis*
$i_{(GSEC\ 1)}$ is not granger caused by **Bank Rate**	3	140.92 (.00)	Reject null hypothesis*
$i_{(GSEC\ 1)}$ is not granger caused by **Spread**	3	39.47 (.00)	Reject null hypothesis*
$i_{(GSEC\ 1)}$ is not granger caused by **Liquidity**	3	34.28 (.00)	Reject null hypothesis*

(contd....)

Table 4 *(Concluded)*

Granger Causality Tests

Null Hypothesis	Number of Lags	$\chi 2$ (calculated)	Conclusion
$i_{(GSEC\ 1)}$ is not granger caused by i^*_2	3	27.75 (.00)	Reject null hypothesis*
$i_{(GSEC\ 1)}$ is not granger caused by **fp_2**	3	104.18 (.00)	Reject null hypothesis*
MODEL D : $i_{(GSec\ 5)}$ = f (π_2, Bank Rate, Spread, Credit, i^*_2, fp_2)			
$i_{(GSEC\ 5)}$ is not granger caused by **p_2**	3	08.22 (.08)	Reject null hypothesis**
$i_{(GSEC\ 5)}$ is not granger caused by **Bank Rate**	3	87.95 (.00)	Reject null hypothesis*
$i_{(GSEC\ 5)}$ is not granger caused by **Spread**	3	19.99 (.00)	Reject null hypothesis*
$i_{(GSEC\ 5)}$ is not granger caused by **Credit**	3	08.77 (.07)	Reject null hypothesis**
$i_{(GSEC\ 5)}$ is not granger caused by i^*_2	3	11.52 (.02)	Reject null hypothesis*
$i_{(GSEC\ 5)}$ is not granger caused by **fp_2**	3	37.74 (.00)	Reject null hypothesis*
MODEL E : $i_{(GSec\ 10)}$ = f (π_2, Bank Rate, Spread, Credit, i^*_2, fp_2)			
$i_{(GSEC\ 10)}$ is not granger caused by π_2	3	10.31 (.04)	Reject null hypothesis*
$i_{(GSEC\ 10)}$ is not granger caused by **Bank Rate**	3	61.04 (.00)	Reject null hypothesis*
$i_{(GSEC\ 10)}$ is not granger caused by **Spread**	3	15.26 (.00)	Reject null hypothesis*
$i_{(GSEC\ 10)}$ is not granger caused by **Credit**	3	10.25 (.00)	Reject null hypothesis*
$i_{(GSEC\ 10)}$ is not granger caused by i^*_2	3	05.98 (.20)	Reject null hypothesis***
$i_{(GSEC\ 10)}$ is not granger caused by **fp_2**	3	26.31 (.00)	Reject null hypothesis*

Note: p-value in parenthesis. *, ** and *** denote significance at 5%, 10% and 20% levels, respectively.
† Week-to-week Inflation has been used as an exogenous variable.

Table 5A

Accuracy of out-of-sample forecasts: Call Money Rate

(January – September 2002)

		ARMA(2,2)		ARMA(2,2) –GARCH(1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
												(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	N*	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U
1	39	1.160		1.014		3.124		3.108		1.522					
2	38	1.208		0.958		2.370		2.293		1.208					
3	37	1.278		0.975		1.828		2.132		1.132					
4	36	1.275	1.230	0.967	0.978	1.384	2.177	2.132	2.416	1.094	1.239	1.253	1.079	1.354	1.366
5	35	1.264		0.972		1.353		2.163		1.079					
6	34	1.197		0.928		1.186		1.944		0.967					
7	33	1.215		0.932		1.121		2.002		0.996					
8	32	1.264	1.235	0.958	0.948	1.117	1.194	2.132	2.060	1.058	1.025	1.236	1.058	1.189	1.018
9	31	1.201		0.918		0.971		1.975		0.972					
10	30	1.193		0.907		0.879		1.889		0.906					
11	29	1.179		0.890		0.806		1.830		0.838					
12	28	1.170	1.186	0.876	0.898	0.785	0.860	1.827	1.880	0.814	0.882	1.058	0.938	1.021	0.862
13	27	1.186		0.879		0.786		1.879		0.826					
14	26	1.163		0.857		0.745		1.856		0.800					
15	25	1.136		0.827		0.700		1.839		0.786					
16	24	1.125	1.153	0.811	0.844	0.653	0.721	1.840	1.854	0.776	0.797	0.930	0.855	0.916	0.770
17	23	1.114		0.788		0.595		1.809		0.763					
18	22	1.113		0.771		0.549		1.737		0.729					
19	21	1.186		0.768		0.552		1.749		0.731					

(contd....)

Table 5A *(Concluded)*

Accuracy of out-of-sample forecasts: Call Money Rate

(January – September 2002)

		ARMA(2,2)		ARMA(2,2) –GARCH(1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
												(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
20	20	1.299	1.178	0.795	0.780	0.600	0.574	1.751	1.762	0.731	0.738	0.880	0.814	0.869	0.709
21	19	1.393		0.795		0.579		1.751		0.636					
22	18	1.440		0.779		0.481		1.738		0.464					
23	17	1.447		0.773		0.478		1.680		0.389					
24	16	1.464	1.436	0.783	0.783	0.462	0.500	1.723	1.723	0.342	0.458	0.648	0.567	0.621	0.436
25	15	1.466		0.788		0.465		1.678		0.317					
26	14	1.437		0.784		0.456		1.610		0.256					
27	13	1.504		0.807		0.479		1.741		0.234					
28	12	1.522	1.482	0.815	0.799	0.477	0.469	1.812	1.710	0.221	0.257	0.378	0.317	0.353	0.255
29	11	1.547		0.814		0.479		1.841		0.217					
30	10	1.592		0.828		0.464		1.873		0.211					
31	9	1.584		0.810		0.428		1.763		0.207					
32	8	1.623	1.587	0.817	0.817	0.421	0.448	1.750	1.807	0.208	0.211	0.380	0.294	0.365	0.188
33	7	1.647		0.818		0.398		1.747		0.233					
34	6	1.664		0.832		0.396		1.679		0.281					
35	5	1.679		0.835		0.332		1.806		0.324					
36	4	1.675	1.666	0.848	0.833	0.233	0.340	1.894	1.781	0.313	0.288	0.620	0.466	0.547	0.254
Average U			1.350		0.853		0.809		1.888		0.655	0.821	0.710	0.804	0.651

* N is the number of observations.

Variables: Inflation (week-to-week), Bank Rate, Spread, Liquidity, Libor-3months and fp-3months.

Table 5B

Accuracy of out-of-sample forecasts: TB 15-91

(January – September 2002)

		ARMA(3,0)		ARMA(3,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.7)
Week-ahead	N*	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U
1	39	0.977		1.016		1.600		1.559		1.264					
2	38	1.067		1.134		1.586		1.911		1.549					
3	37	1.035		1.104		0.999		1.552		1.269					
4	36	1.024	1.026	1.090	1.086	0.871	1.264	1.474	1.624	1.163	1.311	1.177	1.189	1.518	1.260
5	35	0.982		1.046		0.862		1.450		1.075					
6	34	0.984		1.057		0.862		1.502		1.028					
7	33	0.975		1.061		0.787		1.484		0.947					
8	32	0.984	0.981	1.085	1.062	0.840	0.838	1.585	1.505	0.968	1.004	1.182	1.115	1.241	0.925
9	31	0.979		1.092		0.829		1.620		0.951					
10	30	0.982		1.105		0.745		1.567		0.896					
11	29	0.981		1.119		0.699		1.547		0.843					
12	28	0.985	0.982	1.137	1.113	0.696	0.742	1.578	1.578	0.834	0.881	1.097	1.008	1.083	0.824
13	27	0.968		1.127		0.649		1.511		0.793					
14	26	0.962		1.132		0.623		1.530		0.779					
15	25	0.940		1.120		0.633		1.569		0.788					
16	24	0.928	0.950	1.131	1.127	0.666	0.643	1.718	1.582	0.844	0.801	1.008	0.926	1.002	0.750
17	23	0.905		1.131		0.726		1.823		0.903					
18	22	0.907		1.182		0.740		2.035		1.043					
19	21	0.958		1.284		0.819		2.239		1.169					

(contd....)

Table 5B *(Concluded)*

Accuracy of out-of-sample forecasts: TB 15-91

(January – September 2002)

		ARMA(3,0)		ARMA(3,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
20	20	0.999	0.942	1.362	1.240	0.769	0.763	2.254	2.088	1.185	1.075	1.352	1.242	1.363	1.011
21	19	1.052		1.431		0.849		2.143		1.187					
22	18	1.060		1.414		0.688		1.820		0.989					
23	17	1.047		1.366		0.629		1.536		0.863					
24	16	1.050	1.052	1.356	1.392	0.605	0.693	1.392	1.723	0.817	0.964	1.255	1.146	1.298	0.904
25	15	1.034		1.317		0.583		1.173		0.737					
26	14	1.028		1.301		0.511		1.125		0.678					
27	13	1.027		1.299		0.527		1.122		0.649					
28	12	1.025	1.028	1.297	1.304	0.527	0.537	1.120	1.135	0.631	0.674	0.832	0.773	0.899	0.639
29	11	1.024		1.297		0.550		1.063		0.636					
30	10	1.026		1.302		0.541		1.002		0.629					
31	9	1.030		1.307		0.532		0.898		0.612					
32	8	1.024	1.026	1.305	1.303	0.511	0.534	0.811	0.944	0.583	0.615	0.723	0.678	0.800	0.593
33	7	1.025		1.310		0.495		0.752		0.525					
34	6	1.005		1.287		0.518		0.681		0.478					
35	5	1.006		1.296		0.514		0.714		0.454					
36	4	0.973	1.002	1.257	1.287	0.517	0.511	0.703	0.713	0.431	0.472	0.503	0.488	0.591	0.464
Average U			0.999		1.213		0.725		1.432		0.866	1.014	0.952	1.088	0.819

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Liquidity, Libor-3months and fp-3months.

Table 5C

Accuracy of out-of-sample forecasts: 1-year Government Securities

(January – September 2002)

		ARMA(1,0)		ARMA(1,0)— GARCH (1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
												(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	N*	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U	4 Weeks Average U
1	39	0.993		0.995		1.110		1.074		0.820					
2	38	0.989		0.991		0.939		1.023		0.744					
3	37	0.983		0.987		0.870		1.019		0.781					
4	36	0.977	0.985	0.982	0.989	0.826	0.936	0.954	1.017	0.775	0.780	0.813	0.802	0.859	0.766
5	35	0.977		0.984		0.802		0.904		0.754					
6	34	0.975		0.984		0.742		0.824		0.680					
7	33	0.974		0.985		0.704		0.811		0.654					
8	32	0.971	0.974	0.984	0.984	0.659	0.727	0.772	0.828	0.633	0.680	0.741	0.701	0.734	0.680
9	31	0.970		0.985		0.657		0.775		0.632					
10	30	0.969		0.986		0.628		0.738		0.599					
11	29	0.968		0.987		0.618		0.727		0.578					
12	28	0.966	0.968	0.989	0.987	0.632	0.634	0.779	0.755	0.596	0.601	0.644	0.601	0.615	0.604
13	27	0.963		0.987		0.666		0.841		0.623					
14	26	0.970		0.999		0.660		0.890		0.605					
15	25	0.985		1.022		0.664		0.925		0.587					
16	24	0.999	0.979	1.041	1.012	0.719	0.677	1.047	0.926	0.652	0.617	0.646	0.587	0.603	0.620
17	23	1.010		1.057		0.750		1.141		0.710					
18	22	1.039		1.094		0.826		1.311		0.811					
19	21	1.110		1.177		0.997		1.556		0.965					

(contd....)

Table 5C *(Concluded)*

Accuracy of out-of-sample forecasts: 1-year Government Securities

(January – September 2002)

		ARMA(1,0)		ARMA(1,0)—GARCH (1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
												(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
20	20	1.159	1.080	1.237	1.141	1.020	0.898	1.632	1.410	1.010	0.874	0.966	0.845	0.889	0.869
21	19	1.176		1.263		0.976		1.651		0.984					
22	18	1.122		1.223		0.952		1.650		0.887					
23	17	1.103		1.254		0.956		1.951		0.953					
24	16	1.009	1.102	1.146	1.222	0.800	0.921	1.495	1.687	0.717	0.885	1.294	1.007	1.141	0.868
25	15	0.894		1.014		0.593		1.308		0.500					
26	14	0.658		0.746		0.592		1.166		0.461					
27	13	0.517		0.547		0.479		1.071		0.360					
28	12	0.442	0.628	0.466	0.693	0.475	0.535	1.131	1.169	0.370	0.423	0.914	0.654	0.796	0.410
29	11	0.442		0.450		0.524		0.878		0.390					
30	10	0.440		0.437		0.337		0.764		0.362					
31	9	0.438		0.431		0.340		0.665		0.327					
32	8	0.471	0.447	0.458	0.444	0.297	0.374	0.591	0.725	0.314	0.348	0.766	0.572	0.698	0.349
33	7	0.502		0.497		0.411		0.464		0.302					
34	6	0.562		0.563		0.420		0.398		0.296					
35	5	0.557		0.564		0.536		0.278		0.374					
36	4	0.568	0.547	0.577	0.550	0.459	0.457	0.408	0.387	0.340	0.328	0.565	0.464	0.539	0.346
Average U			0.857		0.891		0.684		0.989		0.615	0.817	0.697	0.764	0.612

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Liquidity, Libor-6months and fp-6months.

Table 5D

Accuracy of out-of-sample forecasts: 5-year Government Securities

(January – September 2002)

		ARMA(2,0)		ARMA(2,0) ARCH (2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.1,d=2,k=.5)		Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.5)	Alternative BVAR Models (w=.1, d=2, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
1	39	0.985		0.958		1.260		0.972		0.902					
2	38	0.984		0.944		1.333		0.967		0.895					
3	37	0.970		0.943		1.388		0.944		0.905					
4	36	0.955	0.974	0.939	0.946	1.288	1.317	0.918	0.950	0.904	0.901	0.954	0.910	1.010	0.901
5	35	0.947		0.939		1.237		0.863		0.900					
6	34	0.942		0.940		1.266		0.817		0.910					
7	33	0.934		0.939		1.340		0.786		0.938					
8	32	0.929	0.938	0.938	0.939	1.390	1.308	0.759	0.806	0.965	0.928	1.016	0.957	1.106	0.940
9	31	0.927		0.936		1.415		0.722		0.984					
10	30	0.922		0.934		1.429		0.678		0.982					
11	29	0.919		0.935		1.449		0.637		0.977					
12	28	0.917	0.921	0.938	0.936	1.494	1.447	0.614	0.663	0.993	0.984	1.103	1.028	1.226	1.006
13	27	0.919		0.947		1.562		0.595		1.032					
14	26	0.924		0.961		1.660		0.569		1.096					
15	25	0.936		0.985		1.815		0.558		1.199					
16	24	0.952	0.933	1.017	0.978	2.014	1.763	0.569	0.573	1.342	1.167	1.320	1.216	1.476	1.193
17	23	0.975		1.065		2.298		0.603		1.543					
18	22	1.025		1.149		2.713		0.646		1.846					
19	21	1.172		1.345		3.634		0.744		2.503					

(contd....)

Table 5D *(Concluded)*

Accuracy of out-of-sample forecasts: 5-year Government Securities

(January – September 2002)

		ARMA(2,0)		ARMA(2,0) ARCH (2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.1,d=2,k=.5)		Alternative BVAR Models			
												(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.5)	(w=.1, d=2, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
20	20	1.529	1.175	1.798	1.339	5.514	3.540	0.983	0.744	3.877	2.442	2.730	2.518	3.027	2.491
21	19	1.602		1.926		6.271		1.075		4.505					
22	18	1.334		1.661		5.731		0.997		4.169					
23	17	1.011		1.313		4.809		0.873		3.535					
24	16	0.717	1.166	0.971	1.468	3.982	5.198	0.696	0.910	2.897	3.776	4.214	3.862	4.670	3.845
25	15	0.518		0.709		3.204		0.565		2.340					
26	14	0.384		0.524		2.543		0.461		1.855					
27	13	0.364		0.461		2.081		0.435		1.538					
28	12	0.351	0.404	0.424	0.530	1.821	2.412	0.406	0.467	1.344	1.769	1.994	1.800	2.224	1.800
29	11	0.342		0.404		1.676		0.391		1.216					
30	10	0.314		0.361		1.622		0.376		1.184					
31	9	0.316		0.352		1.553		0.355		1.142					
32	8	0.302	0.319	0.319	0.359	1.441	1.573	0.355	0.369	1.108	1.163	1.315	1.178	1.466	1.180
33	7	0.289		0.273		1.315		0.323		1.075					
34	6	0.287		0.236		1.197		0.279		1.021					
35	5	0.348		0.306		1.058		0.272		0.929					
36	4	0.384	0.327	0.358	0.293	0.970	1.135	0.318	0.298	0.834	0.965	1.066	0.971	1.165	0.976
Average U			0.795		0.865		2.188		0.642		1.566	1.746	1.604	1.930	1.592

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Credit, Libor-6months and fp-6months.

Table 5E

Accuracy of out-of-sample forecasts: 10-year Government Securities

(January – September 2002)

		ARMA(1,0)		ARMA(1,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=2,k=.5)		Alternative BVAR Models			
												(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=1, k=.5)	(w=.2, d=2, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
1	39	0.972		0.959		0.783		0.805		0.847					
2	38	0.967		0.956		0.710		0.748		0.805					
3	37	0.950		0.933		0.700		0.756		0.783					
4	36	0.942	0.958	0.940	0.947	0.725	0.729	0.797	0.776	0.777	0.803	0.824	0.815	0.789	0.796
5	35	0.938		0.943		0.665		0.742		0.710					
6	34	0.931		0.936		0.638		0.715		0.689					
7	33	0.916		0.917		0.602		0.685		0.680					
8	32	0.891	0.919	0.895	0.923	0.600	0.626	0.691	0.708	0.691	0.692	0.704	0.696	0.698	0.687
9	31	0.874		0.889		0.602		0.707		0.673					
10	30	0.872		0.888		0.533		0.645		0.577					
11	29	0.855		0.872		0.507		0.630		0.565					
12	28	0.837	0.860	0.855	0.876	0.486	0.532	0.619	0.650	0.535	0.588	0.594	0.591	0.615	0.587
13	27	0.811		0.833		0.494		0.637		0.539					
14	26	0.792		0.821		0.489		0.642		0.512					
15	25	0.785		0.814		0.469		0.623		0.458					
16	24	0.761	0.787	0.785	0.813	0.445	0.474	0.601	0.626	0.435	0.486	0.486	0.506	0.560	0.496
17	23	0.720		0.746		0.493		0.667		0.502					
18	22	0.662		0.690		0.513		0.710		0.517					
19	21	0.633		0.661		0.512		0.722		0.521					

(contd....)

Table 5E *(Concluded)*

Accuracy of out-of-sample forecasts: 10-year Government Securities

(January – September 2002)

		ARMA(1,0)		ARMA(1,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=2,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.7)
Week-ahead	**N***	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**	**4 Weeks Average U**
20	20	0.636	0.662	0.659	0.689	0.478	0.499	0.703	0.701	0.530	0.517	0.494	0.562	0.667	0.547
21	19	0.611		0.636		0.439		0.710		0.537					
22	18	0.611		0.641		0.371		0.686		0.452					
23	17	0.618		0.658		0.308		0.661		0.347					
24	16	0.661	0.625	0.701	0.659	0.267	0.346	0.615	0.668	0.293	0.407	0.398	0.426	0.499	0.423
25	15	0.643		0.684		0.225		0.594		0.289					
26	14	0.642		0.684		0.196		0.569		0.244					
27	13	0.644		0.689		0.191		0.558		0.224					
28	12	0.638	0.642	0.687	0.686	0.173	0.196	0.544	0.566	0.213	0.242	0.260	0.230	0.235	0.229
29	11	0.631		0.683		0.146		0.518		0.181					
30	10	0.629		0.684		0.125		0.476		0.141					
31	9	0.623		0.680		0.130		0.456		0.149					
32	8	0.613	0.624	0.675	0.681	0.112	0.128	0.433	0.471	0.130	0.150	0.174	0.136	0.134	0.131
33	7	0.608		0.678		0.053		0.395		0.075					
34	6	0.604		0.676		0.026		0.359		0.065					
35	5	0.597		0.671		0.039		0.352		0.045					
36	4	0.589	0.600	0.665	0.672	0.056	0.043	0.346	0.363	0.038	0.056	0.071	0.059	0.098	0.054
Average U			0.742		0.772		0.397		0.614		0.438	0.445	0.447	0.477	0.439

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Credit, Libor-6months and fp-6months.

Table 6A

Accuracy of out-of-sample forecasts: Call Money Rate

(January – September 2002)

		RW		ARMA (2,2)		GARCH (1,1) ARMA (2,2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.7)
Week-ahead	N*	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE
1	39	0.255		0.296		0.258		0.797		0.793		0.389					
2	38	0.333		0.402		0.319		0.788		0.762		0.402					
3	37	0.366		0.467		0.357		0.667		0.778		0.413					
4	36	0.407	0.340	0.519	0.421	0.394	0.332	0.563	0.704	0.867	0.800	0.445	0.412	0.429	0.366	0.458	0.450
5	35	0.442		0.558		0.429		0.597		0.954		0.476					
6	34	0.499		0.597		0.463		0.591		0.969		0.482					
7	33	0.515		0.625		0.480		0.577		1.030		0.512					
8	32	0.519	0.494	0.656	0.609	0.497	0.467	0.579	0.586	1.105	1.014	0.548	0.504	0.608	0.521	0.585	0.501
9	31	0.575		0.690		0.528		0.558		1.135		0.559					
10	30	0.600		0.715		0.544		0.527		1.132		0.543					
11	29	0.633		0.746		0.563		0.510		1.158		0.530					
12	28	0.665	0.618	0.777	0.732	0.582	0.554	0.522	0.529	1.215	1.160	0.541	0.543	0.651	0.578	0.629	0.530
13	27	0.677		0.804		0.595		0.533		1.273		0.559					
14	26	0.723		0.841		0.619		0.538		1.341		0.578					
15	25	0.753		0.855		0.622		0.527		1.384		0.591					
16	24	0.779	0.733	0.876	0.844	0.632	0.617	0.508	0.527	1.432	1.357	0.604	0.583	0.680	0.626	0.670	0.564
17	23	0.807		0.899		0.635		0.480		1.459		0.615					
18	22	0.830		0.923		0.640		0.455		1.441		0.605					
19	21	0.796		0.944		0.611		0.439		1.391		0.581					

(contd....)

Table 6A *(Concluded)*

Accuracy of out-of-sample forecasts: Call Money Rate

(January – September 2002)

		RW		ARMA (2,2)		GARCH (1,1) ARMA (2,2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
														(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
20	20	0.748	0.795	0.971	0.934	0.594	0.620	0.449	0.456	1.309	1.400	0.546	0.587	0.699	0.647	0.690	0.564
21	19	0.727		1.012		0.578		0.420		1.272		0.462					
22	18	0.738		1.063		0.575		0.355		1.283		0.343					
23	17	0.761		1.102		0.589		0.364		1.279		0.296					
24	16	0.777	0.751	1.137	1.079	0.608	0.587	0.359	0.375	1.338	1.293	0.266	0.342	0.485	0.423	0.464	0.325
25	15	0.801		1.174		0.631		0.372		1.344		0.254					
26	14	0.847		1.217		0.664		0.386		1.363		0.217					
27	13	0.822		1.235		0.663		0.394		1.430		0.192					
28	12	0.826	0.824	1.257	1.221	0.674	0.658	0.394	0.387	1.497	1.408	0.183	0.211	0.311	0.260	0.290	0.210
29	11	0.820		1.269		0.668		0.392		1.509		0.178					
30	10	0.806		1.284		0.668		0.374		1.510		0.170					
31	9	0.820		1.299		0.664		0.351		1.445		0.170					
32	8	0.810	0.814	1.315	1.292	0.662	0.665	0.341	0.365	1.418	1.470	0.168	0.172	0.309	0.239	0.297	0.153
33	7	0.807		1.328		0.660		0.321		1.410		0.188					
34	6	0.812		1.350		0.675		0.321		1.362		0.228					
35	5	0.814		1.366		0.680		0.270		1.470		0.264					
36	4	0.831	0.816	1.392	1.359	0.704	0.680	0.193	0.276	1.570	1.453	0.260	0.235	0.506	0.380	0.446	0.207
Average U			0.687		0.943		0.576		0.467		1.262		0.399	0.520	0.449	0.503	0.389

* N is the number of observations.

Variables: Inflation (week-to-week), Bank Rate, Spread, Liquidity, Libor-3months and fp-3months.

Table 6B

Accuracy of out-of-sample forecasts: TB 15-91

(January – September 2002)

		RW		ARMA (3,0)		ARMA(3,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
														(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	N*	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE
1	39	0.219		0.214		0.223		0.171		0.342		0.277					
2	38	0.232		0.247		0.263		0.295		0.443		0.359					
3	37	0.292		0.302		0.322		0.375		0.453		0.370					
4	36	0.334	0.269	0.343	0.277	0.364	0.293	0.427	0.317	0.493	0.433	0.389	0.349	0.319	0.321	0.409	0.332
5	35	0.396		0.389		0.414		0.484		0.574		0.425					
6	34	0.424		0.417		0.448		0.542		0.637		0.436					
7	33	0.452		0.440		0.479		0.575		0.670		0.428					
8	32	0.455	0.432	0.448	0.424	0.494	0.459	0.580	0.545	0.721	0.650	0.440	0.432	0.510	0.480	0.534	0.398
9	31	0.472		0.462		0.516		0.587		0.765		0.449					
10	30	0.495		0.486		0.547		0.604		0.776		0.443					
11	29	0.510		0.500		0.571		0.619		0.789		0.430					
12	28	0.516	0.498	0.509	0.489	0.587	0.555	0.617	0.607	0.815	0.786	0.431	0.438	0.546	0.502	0.539	0.410
13	27	0.542		0.525		0.611		0.620		0.819		0.429					
14	26	0.552		0.531		0.625		0.646		0.845		0.430					
15	25	0.551		0.518		0.617		0.646		0.865		0.434					
16	24	0.520	0.541	0.483	0.514	0.588	0.610	0.622	0.633	0.894	0.856	0.439	0.433	0.546	0.501	0.542	0.406
17	23	0.497		0.450		0.562		0.584		0.906		0.448					
18	22	0.443		0.402		0.523		0.546		0.901		0.462					
19	21	0.383		0.367		0.492		0.506		0.858		0.448					

(contd....)

Table 6B *(Concluded)*

Accuracy of out-of-sample forecasts: TB 15-91

(January – September 2002)

		RW		ARMA (3,0)		ARMA(3,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
														(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
20	20	0.369	0.423	0.369	0.397	0.503	0.520	0.486	0.531	0.833	0.874	0.437	0.449	0.564	0.518	0.568	0.422
21	19	0.361		0.379		0.516		0.468		0.773		0.428					
22	18	0.415		0.440		0.586		0.460		0.755		0.410					
23	17	0.481		0.504		0.658		0.479		0.739		0.416					
24	16	0.531	0.447	0.557	0.470	0.720	0.620	0.508	0.479	0.739	0.752	0.433	0.422	0.549	0.501	0.569	0.396
25	15	0.603		0.623		0.794		0.496		0.707		0.445					
26	14	0.663		0.682		0.862		0.480		0.746		0.449					
27	13	0.692		0.711		0.899		0.487		0.777		0.449					
28	12	0.725	0.671	0.743	0.690	0.940	0.874	0.515	0.494	0.812	0.760	0.458	0.450	0.555	0.516	0.600	0.427
29	11	0.763		0.782		0.990		0.516		0.812		0.486					
30	10	0.798		0.819		1.039		0.508		0.800		0.502					
31	9	0.836		0.860		1.092		0.463		0.750		0.512					
32	8	0.882	0.820	0.903	0.841	1.151	1.068	0.488	0.494	0.715	0.769	0.514	0.504	0.591	0.555	0.654	0.485
33	7	0.925		0.947		1.212		0.501		0.696		0.485					
34	6	1.001		1.006		1.288		0.317		0.682		0.479					
35	5	1.040		1.046		1.348		0.350		0.743		0.473					
36	4	1.135	1.025	1.105	1.026	1.426	1.318	0.352	0.380	0.798	0.730	0.489	0.481	0.510	0.496	0.601	0.474
Average U			0.570		0.570		0.702		0.498		0.734		0.440	0.521	0.488	0.557	0.417

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Liquidity, Libor-3months and fp-3months.

Table 6C

Accuracy of out-of-sample forecasts: 1-year Government Securities

(January – September 2002)

		RW		ARMA (1,0)		ARMA(1,0) GARCH (1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models			
														(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
1	39	0.286		0.284		0.285		0.318		0.307		0.235					
2	38	0.385		0.381		0.382		0.362		0.394		0.287					
3	37	0.455		0.447		0.449		0.396		0.463		0.355					
4	36	0.518	0.411	0.506	0.404	0.508	0.406	0.427	0.376	0.494	0.414	0.401	0.319	0.336	0.331	0.356	0.313
5	35	0.572		0.559		0.563		0.459		0.517		0.431					
6	34	0.655		0.638		0.644		0.486		0.539		0.445					
7	33	0.711		0.693		0.701		0.501		0.577		0.465					
8	32	0.760	0.675	0.738	0.657	0.748	0.664	0.501	0.487	0.587	0.555	0.481	0.456	0.497	0.469	0.491	0.455
9	31	0.772		0.749		0.761		0.507		0.599		0.488					
10	30	0.801		0.776		0.790		0.503		0.591		0.480					
11	29	0.827		0.800		0.816		0.511		0.601		0.478					
12	28	0.818	0.805	0.791	0.779	0.809	0.794	0.518	0.510	0.638	0.607	0.488	0.483	0.518	0.483	0.494	0.486
13	27	0.814		0.784		0.804		0.543		0.685		0.508					
14	26	0.767		0.744		0.767		0.507		0.683		0.464					
15	25	0.716		0.705		0.731		0.475		0.662		0.420					
16	24	0.676	0.743	0.675	0.727	0.703	0.751	0.486	0.503	0.707	0.684	0.440	0.458	0.480	0.436	0.448	0.461
17	23	0.643		0.650		0.680		0.483		0.734		0.457					
18	22	0.567		0.590		0.621		0.469		0.744		0.460					
19	21	0.475		0.527		0.558		0.473		0.738		0.458					

(contd....)

Table 6C *(Concluded)*

Accuracy of out-of-sample forecasts: 1-year Government Securities

(January – September 2002)

		RW		ARMA (1,0)		ARMA(1,0) GARCH (1,1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=1,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
20	20	0.434	0.530	0.504	0.567	0.537	0.599	0.443	0.467	0.709	0.731	0.439	0.453	0.500	0.438	0.460	0.451
21	19	0.413		0.485		0.521		0.403		0.681		0.406					
22	18	0.399		0.447		0.487		0.380		0.658		0.353					
23	17	0.315		0.347		0.395		0.301		0.614		0.300					
24	16	0.369	0.374	0.373	0.413	0.423	0.457	0.295	0.345	0.552	0.626	0.265	0.331	0.479	0.374	0.423	0.325
25	15	0.425		0.380		0.430		0.252		0.555		0.212					
26	14	0.449		0.296		0.335		0.266		0.523		0.207					
27	13	0.522		0.270		0.286		0.250		0.559		0.188					
28	12	0.529	0.481	0.234	0.295	0.247	0.325	0.251	0.255	0.598	0.559	0.196	0.201	0.436	0.313	0.380	0.195
29	11	0.591		0.261		0.266		0.310		0.519		0.231					
30	10	0.655		0.288		0.286		0.221		0.500		0.237					
31	9	0.707		0.309		0.304		0.240		0.470		0.231					
32	8	0.798	0.688	0.375	0.308	0.365	0.305	0.237	0.252	0.471	0.490	0.250	0.237	0.525	0.392	0.478	0.238
33	7	0.870		0.437		0.433		0.357		0.403		0.263					
34	6	0.994		0.558		0.559		0.418		0.395		0.294					
35	5	1.044		0.581		0.589		0.559		0.290		0.390					
36	4	1.171	1.020	0.665	0.560	0.675	0.564	0.538	0.468	0.478	0.392	0.398	0.336	0.568	0.469	0.545	0.356
Average U			0.636		0.523		0.541		0.407		0.562		0.364	0.482	0.412	0.453	0.364

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Liquidity, Libor-6months and fp-6months

Table 6D

Accuracy of out-of-sample forecasts: 5-year Government Securities

(January – September 2002)

		RW		ARMA (2,0)		ARMA(2,0) ARCH (2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.1,d=2,k=.5)		Alternative BVAR Models			
														(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.5)	(w=.1, d=2, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
1	39	0.139		0.137		0.133		0.175		0.135		0.125					
2	38	0.227		0.224		0.214		0.303		0.220		0.203					
3	37	0.300		0.291		0.283		0.417		0.284		0.272					
4	36	0.368	0.259	0.351	0.251	0.345	0.244	0.474	0.342	0.337	0.244	0.332	0.233	0.248	0.236	0.265	0.233
5	35	0.423		0.400		0.397		0.523		0.365		0.380					
6	34	0.471		0.444		0.443		0.597		0.385		0.429					
7	33	0.507		0.474		0.476		0.680		0.399		0.476					
8	32	0.536	0.484	0.498	0.454	0.503	0.455	0.745	0.636	0.406	0.389	0.517	0.451	0.493	0.465	0.537	0.456
9	31	0.555		0.515		0.520		0.785		0.401		0.546					
10	30	0.579		0.534		0.541		0.828		0.393		0.568					
11	29	0.605		0.556		0.565		0.876		0.385		0.591					
12	28	0.624	0.591	0.573	0.544	0.586	0.553	0.933	0.855	0.383	0.391	0.620	0.581	0.652	0.607	0.725	0.594
13	27	0.635		0.583		0.601		0.991		0.378		0.655					
14	26	0.629		0.581		0.605		1.045		0.358		0.690					
15	25	0.607		0.568		0.598		1.101		0.339		0.727					
16	24	0.576	0.611	0.548	0.570	0.585	0.597	1.159	1.074	0.328	0.351	0.772	0.711	0.804	0.741	0.899	0.727
17	23	0.530		0.517		0.565		1.219		0.320		0.819					
18	22	0.466		0.478		0.535		1.265		0.301		0.861					
19	21	0.358		0.419		0.481		1.300		0.266		0.895					

(contd....)

Table 6D *(Concluded)*

Accuracy of out-of-sample forecasts: 5-year Government Securities

(January – September 2002)

		RW		ARMA (2,0)		ARMA(2,0) ARCH (2)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.1,d=2,k=.5)		Alternative BVAR Models			
														(w=.1, d=1, k=.5)	(w=.2, d=2, k=.5)	(w=.2, d=1, k=.5)	(w=.1, d=2, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
20	20	0.239	0.398	0.366	0.445	0.430	0.503	1.320	1.276	0.235	0.281	0.928	0.876	0.980	0.904	1.087	0.893
21	19	0.208		0.334		0.401		1.306		0.224		0.938					
22	18	0.220		0.294		0.366		1.262		0.219		0.918					
23	17	0.248		0.251		0.326		1.193		0.217		0.877					
24	16	0.295	0.243	0.212	0.272	0.287	0.345	1.176	1.234	0.206	0.216	0.856	0.897	1.002	0.917	1.110	0.913
25	15	0.361		0.187		0.256		1.157		0.204		0.845					
26	14	0.446		0.171		0.234		1.134		0.206		0.827					
27	13	0.528		0.192		0.243		1.098		0.229		0.812					
28	12	0.596	0.483	0.209	0.190	0.253	0.246	1.086	1.119	0.242	0.220	0.802	0.821	0.926	0.836	1.033	0.836
29	11	0.653		0.223		0.264		1.094		0.255		0.794					
30	10	0.693		0.218		0.250		1.125		0.261		0.821					
31	9	0.746		0.236		0.263		1.159		0.265		0.852					
32	8	0.808	0.725	0.244	0.230	0.258	0.259	1.164	1.135	0.287	0.267	0.895	0.840	0.951	0.852	1.059	0.853
33	7	0.872		0.252		0.238		1.147		0.282		0.938					
34	6	0.945		0.271		0.222		1.131		0.264		0.964					
35	5	1.053		0.366		0.323		1.114		0.286		0.978					
36	4	1.172	1.011	0.450	0.335	0.419	0.301	1.137	1.132	0.373	0.301	0.978	0.965	1.065	0.970	1.163	0.976
Average U			0.534		0.366		0.389		0.978		0.295		0.708	0.791	0.725	0.876	0.720

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Credit, Libor-6months and fp-6months.

Table 6E

Accuracy of out-of-sample forecasts: 10-year Government Securities

(January – September 2002)

		RW		ARMA (1,0)		ARMA(1,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=2,k=.5)		Alternative BVAR Models			
														(w=.1, d=2, k=.5)	(w=.1, d=1, k=.5)	(w=.2, d=1, k=.5)	(w=.2, d=2, k=.7)
Week-ahead	N*	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE	4 Weeks Average RMSE
1	39	0.335		0.326		0.322		0.263		0.270		0.284					
2	38	0.394		0.380		0.376		0.279		0.295		0.317					
3	37	0.430		0.408		0.401		0.301		0.325		0.336					
4	36	0.434	0.398	0.409	0.381	0.408	0.377	0.314	0.289	0.346	0.309	0.337	0.319	0.327	0.323	0.313	0.316
5	35	0.511		0.480		0.482		0.340		0.379		0.363					
6	34	0.584		0.544		0.547		0.373		0.418		0.403					
7	33	0.609		0.558		0.559		0.367		0.417		0.414					
8	32	0.610	0.579	0.544	0.531	0.546	0.534	0.366	0.361	0.422	0.409	0.422	0.400	0.407	0.403	0.403	0.397
9	31	0.613		0.535		0.544		0.369		0.433		0.412					
10	30	0.663		0.578		0.589		0.354		0.428		0.383					
11	29	0.684		0.585		0.597		0.347		0.431		0.387					
12	28	0.712	0.668	0.596	0.574	0.609	0.585	0.346	0.354	0.441	0.433	0.381	0.391	0.395	0.393	0.410	0.390
13	27	0.728		0.591		0.606		0.360		0.464		0.392					
14	26	0.715		0.566		0.587		0.350		0.459		0.366					
15	25	0.721		0.566		0.587		0.339		0.449		0.330					
16	24	0.704	0.717	0.536	0.565	0.553	0.583	0.313	0.340	0.423	0.449	0.306	0.349	0.349	0.363	0.402	0.356
17	23	0.693		0.499		0.516		0.341		0.462		0.347					
18	22	0.644		0.426		0.444		0.330		0.457		0.333					
19	21	0.621		0.393		0.411		0.318		0.449		0.324					

(contd....)

Table 6E *(Concluded)*

Accuracy of out-of-sample forecasts: 10-year Government Securities

(January – September 2002)

		RW		ARMA (1,0)		ARMA(1,0) ARCH (1)		LVAR (LAG 4)		VECM (LAG 4)		Optimal BVAR Model (w=.2,d=2,k=.5)		Alternative BVAR Models (w=.1, d=2, k=.5)	Alternative BVAR Models (w=.1, d=1, k=.5)	Alternative BVAR Models (w=.2, d=1, k=.5)	Alternative BVAR Models (w=.2, d=2, k=.7)
Week-ahead	**N***	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**	**4 Weeks Average RMSE**
20	20	0.642	0.650	0.408	0.431	0.423	0.449	0.307	0.324	0.451	0.455	0.340	0.336	0.321	0.365	0.433	0.355
21	19	0.672		0.410		0.427		0.295		0.477		0.361					
22	18	0.742		0.453		0.475		0.275		0.509		0.335					
23	17	0.811		0.501		0.533		0.249		0.536		0.282					
24	16	0.890	0.779	0.588	0.488	0.624	0.515	0.237	0.264	0.547	0.517	0.261	0.310	0.303	0.323	0.378	0.321
25	15	0.960		0.617		0.657		0.216		0.570		0.277					
26	14	1.046		0.671		0.716		0.206		0.595		0.255					
27	13	1.127		0.726		0.777		0.215		0.629		0.252					
28	12	1.139	1.068	0.727	0.685	0.783	0.733	0.197	0.208	0.620	0.604	0.243	0.257	0.276	0.243	0.247	0.242
29	11	1.167		0.737		0.798		0.171		0.605		0.211					
30	10	1.210		0.761		0.828		0.151		0.575		0.171					
31	9	1.283		0.800		0.872		0.166		0.586		0.191					
32	8	1.310	1.243	0.803	0.775	0.884	0.845	0.146	0.159	0.567	0.583	0.170	0.186	0.215	0.168	0.167	0.162
33	7	1.321		0.804		0.896		0.070		0.522		0.099					
34	6	1.418		0.856		0.958		0.036		0.510		0.093					
35	5	1.436		0.857		0.964		0.056		0.506		0.064					
36	4	1.452	1.407	0.856	0.843	0.966	0.946	0.081	0.061	0.502	0.510	0.055	0.078	0.099	0.083	0.137	0.075
Average U			0.834		0.586		0.618		0.262		0.474		0.292	0.299	0.296	0.321	0.291

* N is the number of observations.

Variables: Inflation (year-on-year), Bank Rate, Spread, Credit, Libor-6months and fp-6months.

Table 7A

Comparison of out-of-sample forecasts: Call Money Rate

(January – September 2002)

		LVAR (LAG 4)			VECM (LAG 4)			Optimal BVAR Model(w=.2,d=1,k=.5)		
Week-ahead	**N***	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**
4	36	2.177	2.101	-3.451	2.416	2.428	0.485	1.239	1.266	2.186
8	32	1.194	1.357	13.627	2.060	1.967	-4.506	1.025	1.068	4.206
12	28	0.860	1.108	28.777	1.880	1.709	-9.121	0.882	0.957	8.487
16	24	0.721	1.008	39.776	1.854	1.686	-9.068	0.797	0.890	11.656
20	20	0.574	0.847	47.533	1.762	1.574	-10.633	0.738	0.874	18.401
24	16	0.500	0.483	-3.439	1.723	1.497	-13.142	0.458	0.637	39.191
28	12	0.469	0.272	-42.089	1.710	1.501	-12.257	0.257	0.496	93.212
32	8	0.448	0.302	-32.650	1.807	1.598	-11.537	0.211	0.689	226.972
36	4	0.340	0.317	-6.688	1.781	1.663	-6.661	0.288	0.933	224.020
Average U		0.809	0.866	7.018	1.888	1.736	-8.069	0.655	0.868	32.503

* N is the number of observations. Increase in U implies deterioration in forecast accuracy.
Variables: Inflation (week-to-week), Bank Rate/Repo, Spread, Liquidity, Libor-3months and fp-3months

Table 7B

Comparison of out-of-sample forecasts: TB 15-91
(January – September 2002)

		LVAR (LAG 4)			VECM (LAG 4)			Optimal BVAR Model(w=.2,d=1,k=.5)		
Week-ahead	**N***	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**
4	36	1.264	1.418	12.179	1.624	1.583	-2.543	1.311	1.219	-7.032
8	32	0.838	0.853	1.806	1.505	1.316	-12.577	1.004	0.995	-0.931
12	28	0.742	0.825	11.167	1.578	1.439	-8.819	0.881	0.884	0.364
16	24	0.643	0.762	18.501	1.582	1.462	-7.583	0.801	0.787	-1.734
20	20	0.763	1.010	32.276	2.088	2.018	-3.349	1.075	1.047	-2.587
24	16	0.693	0.768	10.854	1.723	1.912	10.956	0.964	0.871	-9.688
28	12	0.537	0.323	-39.869	1.135	1.379	21.499	0.674	0.507	-24.760
32	8	0.534	0.270	-49.419	0.944	1.260	33.551	0.615	0.442	-28.185
36	4	0.511	0.200	-60.805	0.713	1.014	42.322	0.472	0.292	-38.063
Average U		0.725	0.714	-1.473	1.432	1.487	3.811	0.866	0.783	-9.662

* N is the number of observations. Increase in U implies deterioration in forecast accuracy.
Variables: Inflation (year-on-year), Bank Rate/Repo, Spread, Liquidity, Libor-3months and fp-3months.

Table 7C

Comparison of out-of-sample forecasts: 1-year Government Securities
(January – September 2002)

		LVAR (LAG 4)			VECM (LAG 4)			Optimal BVAR Model(w=.2,d=1,k=.5)		
Week-ahead	**N***	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**
4	36	0.936	1.023	9.229	1.017	1.070	5.163	0.780	0.802	2.777
8	32	0.727	0.723	-0.479	0.828	0.814	-1.619	0.680	0.687	1.020
12	28	0.634	0.589	-7.090	0.755	0.707	-6.308	0.601	0.598	-0.521
16	24	0.677	0.605	-10.674	0.926	0.783	-15.387	0.617	0.621	0.738
20	20	0.898	0.857	-4.612	1.410	1.169	-17.098	0.874	0.916	4.816
24	16	0.921	0.873	-5.215	1.687	1.593	-5.587	0.885	0.959	8.347
28	12	0.535	0.484	-9.456	1.169	1.236	5.739	0.423	0.461	8.963
32	8	0.374	0.320	-14.429	0.725	0.849	17.168	0.348	0.368	5.594
36	4	0.457	0.381	-16.472	0.387	0.551	42.360	0.328	0.314	-4.093
Average U		0.684	0.651	-4.929	0.989	0.975	-1.470	0.615	0.636	3.431

* N is the number of observations. Increase in U implies deterioration in forecast accuracy.
Variables: Inflation (year-on-year), Bank Rate/Repo, Spread, Liquidity, Libor-6months and fp-6months.

Table 7D

Comparison of out-of-sample forecasts: 5-year Government Securities

(January – September 2002)

		LVAR (LAG 4)			VECM (LAG 4)			Optimal BVAR Model(w=.1,d=2,k=.5)		
Week-ahead	**N***	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**
4	36	1.317	1.273	-3.326	0.950	0.972	2.330	0.901	0.927	2.863
8	32	1.308	1.158	-11.529	0.806	0.834	3.412	0.928	0.981	5.708
12	28	1.447	1.223	-15.476	0.663	0.676	2.073	0.984	1.041	5.807
16	24	1.763	1.443	-18.162	0.573	0.556	-2.988	1.167	1.212	3.837
20	20	3.540	2.884	-18.534	0.744	0.632	-15.000	2.442	2.468	1.038
24	16	5.198	4.208	-19.051	0.910	0.932	2.369	3.776	3.758	-0.491
28	12	2.412	1.952	-19.073	0.467	0.656	40.506	1.769	1.743	-1.483
32	8	1.573	1.273	-19.068	0.369	0.551	49.129	1.163	1.137	-2.183
36	4	1.135	0.978	-13.794	0.298	0.433	45.204	0.965	0.940	-2.536
Average U		2.188	1.821	-16.766	0.642	0.694	7.984	1.566	1.579	0.791

* N is the number of observations. Increase in U implies deterioration in forecast accuracy.
Variables: Inflation (year-on-year), Bank Rate/Repo, Spread, Credit, Libor-6months and fp-6months.

Table 7E

Comparison of out-of-sample forecasts: 10-year Government Securities

(January – September 2002)

		LVAR (LAG 4)			VECM (LAG 4)			Optimal BVAR Model(w=.2,d=2,k=.5)		
Week-ahead	**N***	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**	**4 weeks Average U With BankRate**	**4 weeks Average U With Repo**	**% Increase in U**
4	36	0.729	0.687	-5.754	0.776	0.759	-2.296	0.803	0.801	-0.282
8	32	0.626	0.591	-5.577	0.708	0.716	1.057	0.692	0.692	-0.061
12	28	0.532	0.495	-6.936	0.650	0.662	1.764	0.588	0.594	1.139
16	24	0.474	0.435	-8.320	0.626	0.655	4.652	0.486	0.504	3.768
20	20	0.499	0.451	-9.525	0.701	0.728	3.923	0.517	0.534	3.213
24	16	0.346	0.329	-4.778	0.668	0.714	6.809	0.407	0.405	-0.582
28	12	0.196	0.194	-1.220	0.566	0.631	11.384	0.242	0.237	-2.050
32	8	0.128	0.125	-2.508	0.471	0.553	17.422	0.150	0.146	-2.588
36	4	0.043	0.041	-4.336	0.363	0.453	24.921	0.056	0.054	-3.848
Average U		0.397	0.372	-6.289	0.614	0.652	6.152	0.438	0.441	0.649

* N is the number of observations. Increase in U implies deterioration in forecast accuracy.
Variables: Inflation (year-on-year), Bank Rate/Repo, Spread, Liquidity, Libor-6months and fp-6months.

Call Money Rate

Univariate Models

Fig 1.1A: 1-week-ahead Forecasts

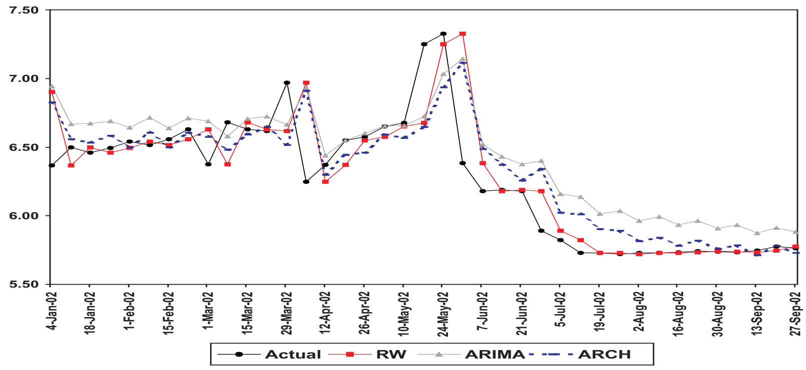


Fig 1.2A: 4-week-ahead Forecasts

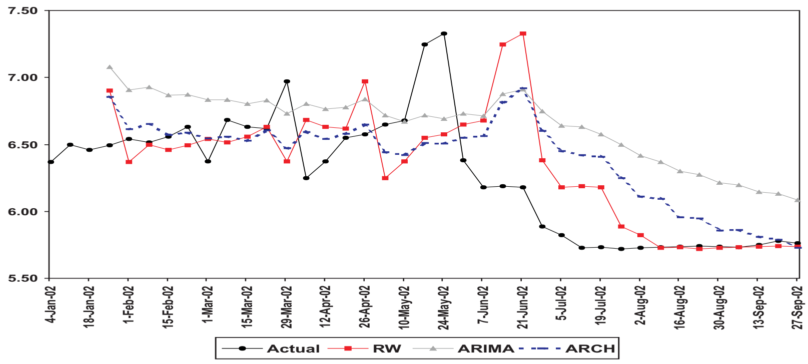
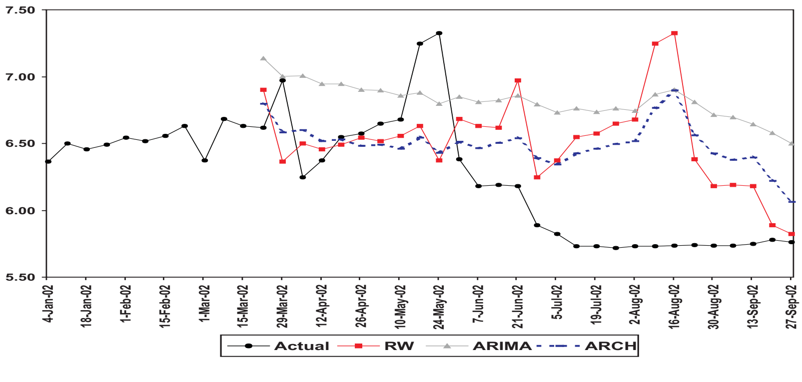


Fig 1.3A: 12-week-ahead Forecasts



Call Money Rate

Multivariate Models

Fig 2.1A: 1-week-ahead Forecasts

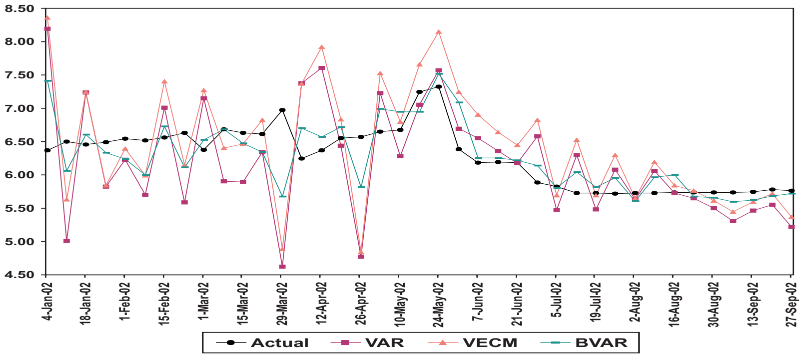


Fig 2.2A: 4-week-ahead Forecasts

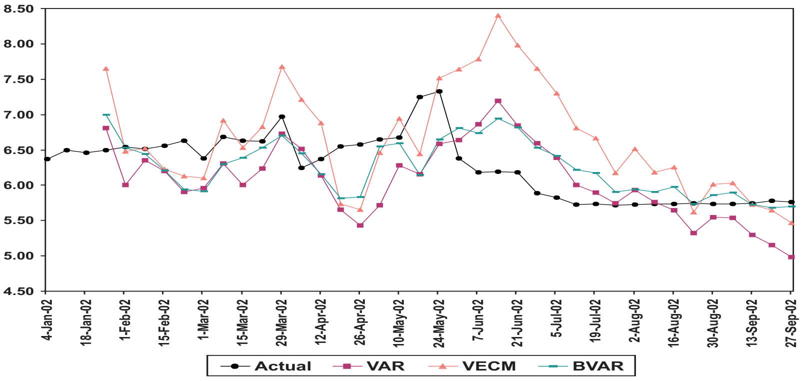
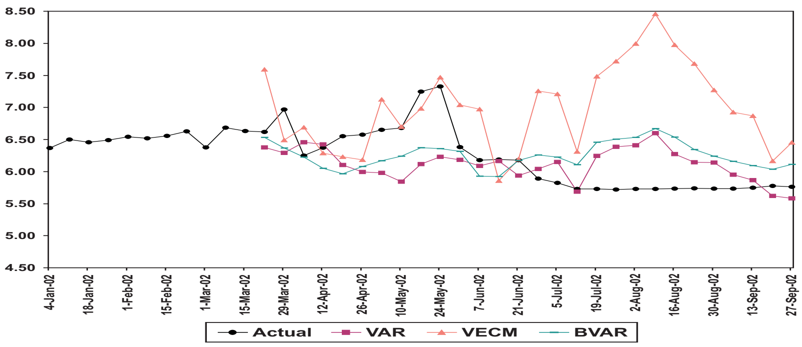


Fig 2.3A: 12-week-ahead Forecasts



Call Money Rate
"Best" Univariate vs. "Best" Multivariate Model

Fig 3.1A: 1-week-ahead Forecasts

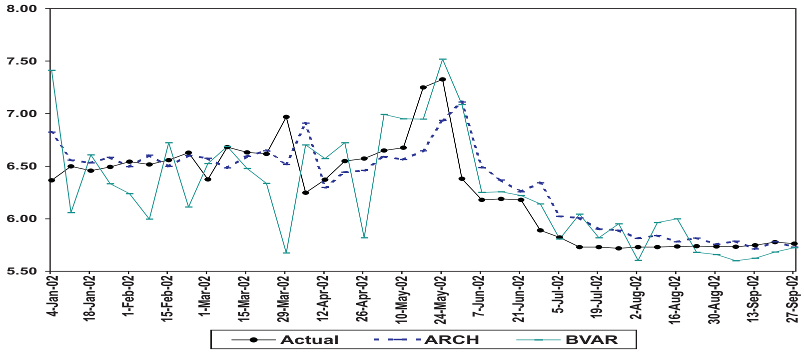


Fig 3.2A: 4-week-ahead Forecasts

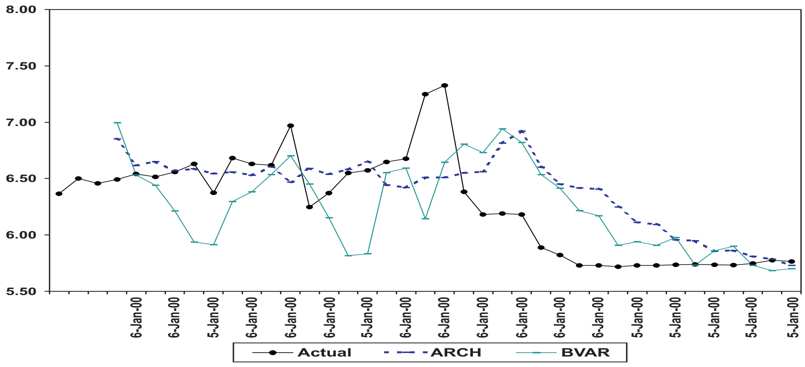
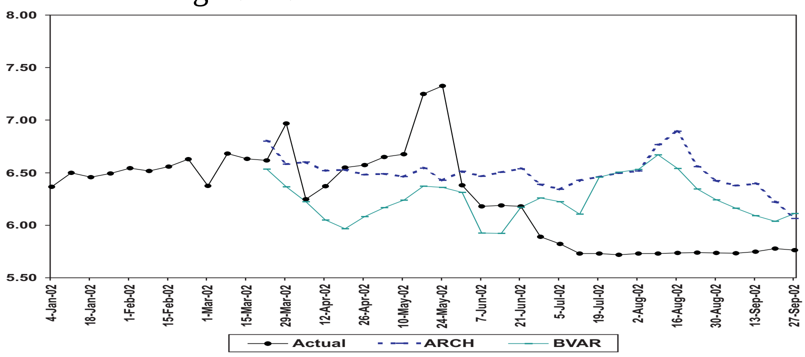


Fig 3.3A: 12-week-ahead Forecasts



TB 15-91

Univariate Models

Fig 1.1B: 1-week-ahead Forecasts

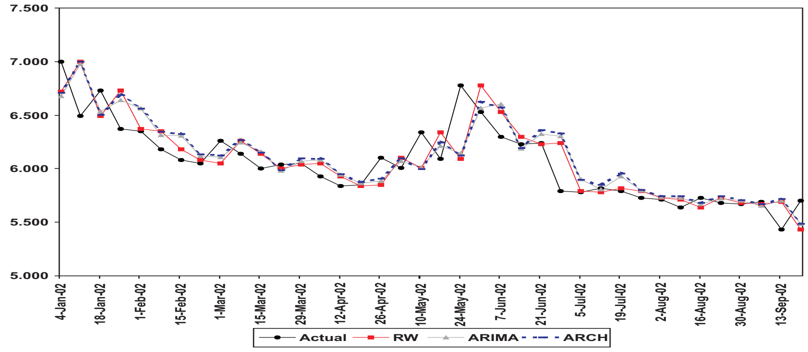


Fig 1.2B: 4-week-ahead Forecasts

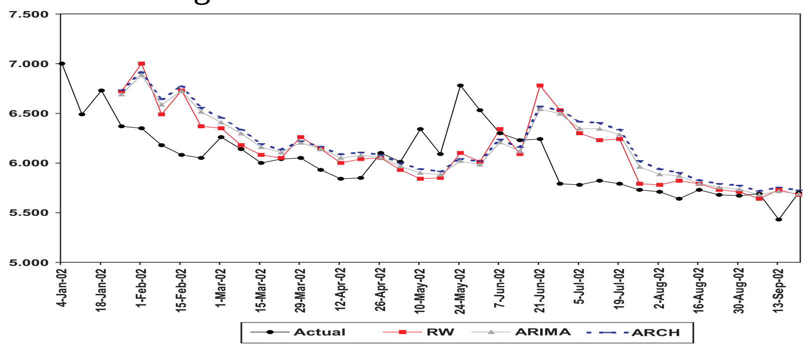
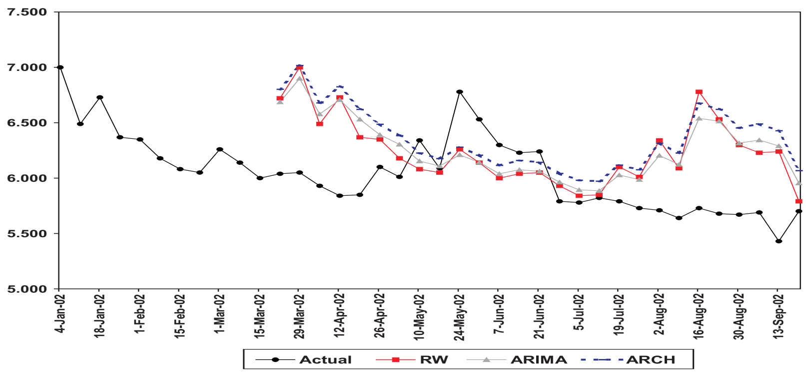


Fig 1.3B: 12-week-ahead Forecasts



TB 15-91
Multivariate Models

Fig 2.1B: 1-week-ahead Forecasts

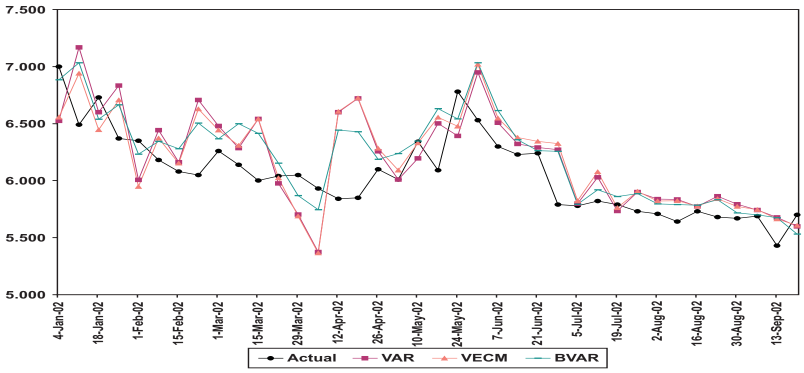


Fig 2.2B: 4-week-ahead Forecasts

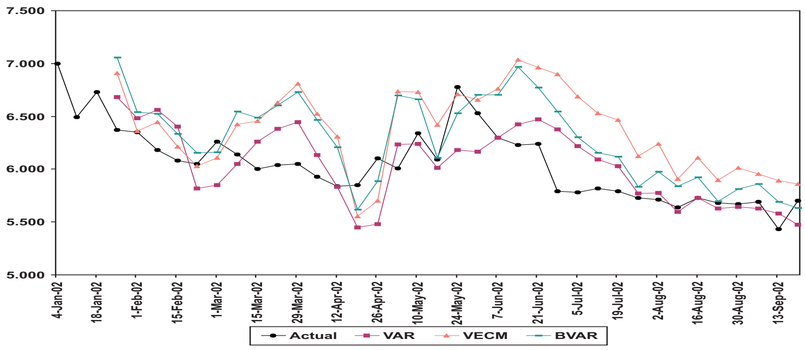
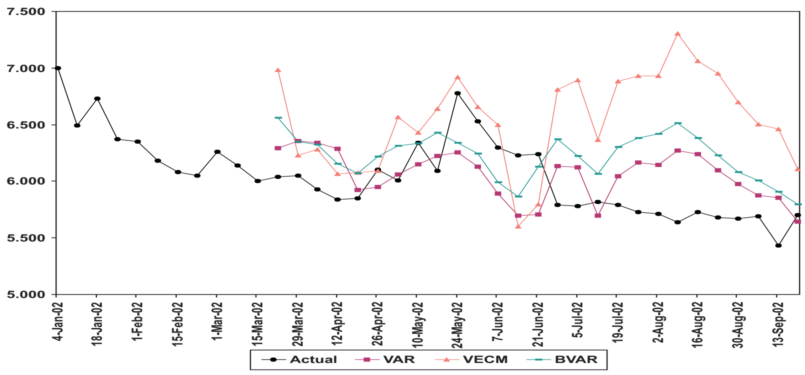


Fig 2.3B: 12-week-ahead Forecasts



TB 15-91
"Best" Univariate vs. "Best" Multivariate Model

Fig 3.1B: 1-week-ahead Forecasts

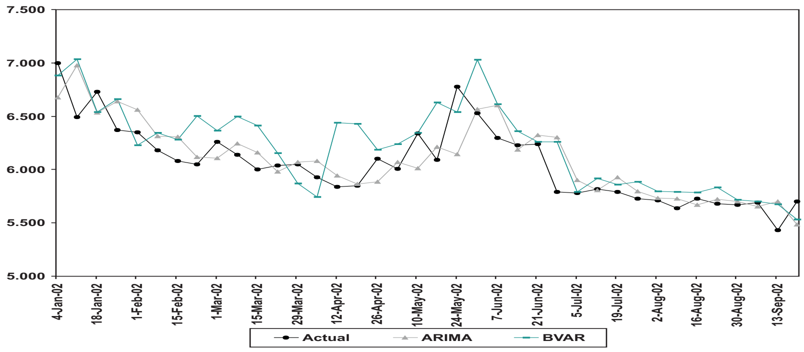


Fig 3.2B: 4-week-ahead Forecasts

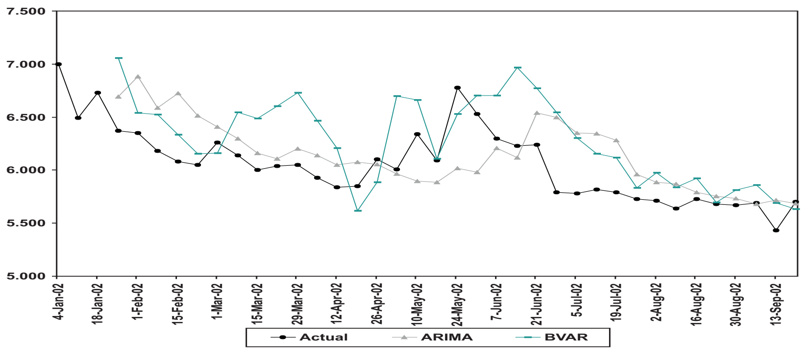
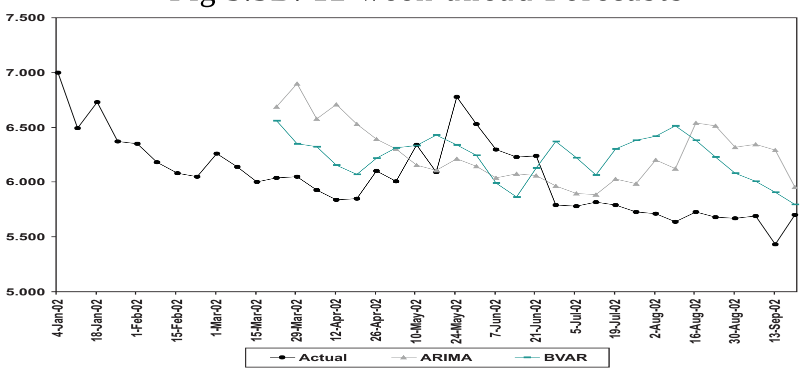


Fig 3.3B: 12-week-ahead Forecasts



GSec 1
Univariate Models

Fig 1.1C: 1-week-ahead Forecasts

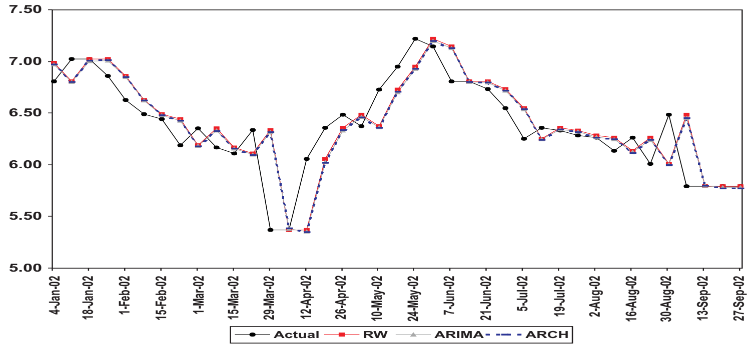


Fig 1.2C: 4-week-ahead Forecasts

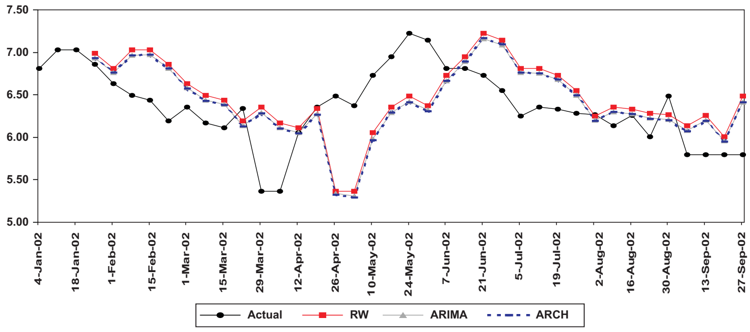
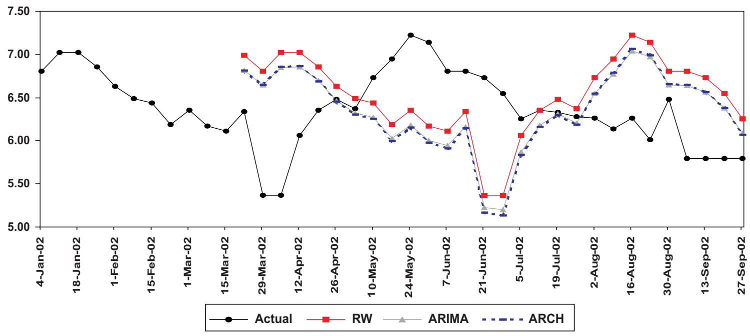


Fig 1.3C: 12-week-ahead Forecasts



GSec 1
Multivariate Models

Fig 2.1C: 1-week-ahead Forecasts

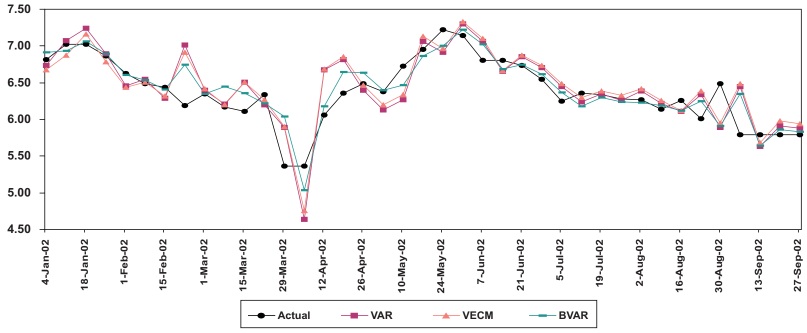


Fig 2.2C: 4-week-ahead Forecasts

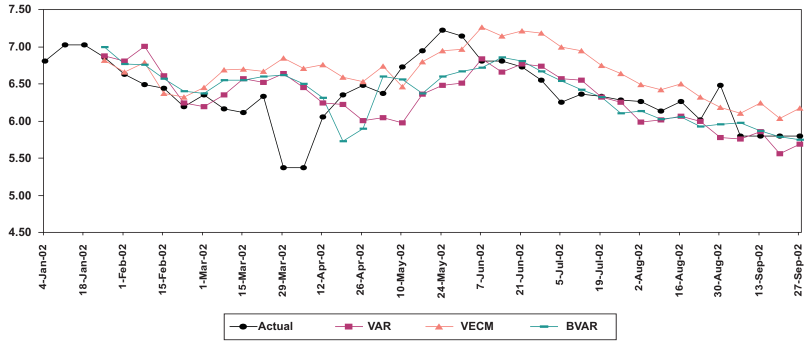
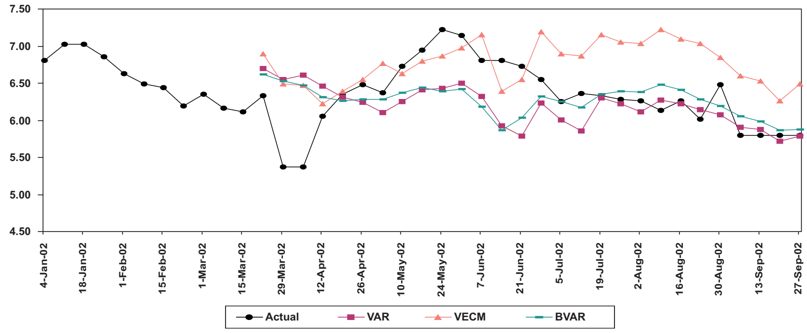


Fig 2.3C: 12-week-ahead Forecasts



GSec 1
"Best" Univariate vs. "Best" Multivariate Model

Fig 3.1C: 1-week-ahead Forecasts

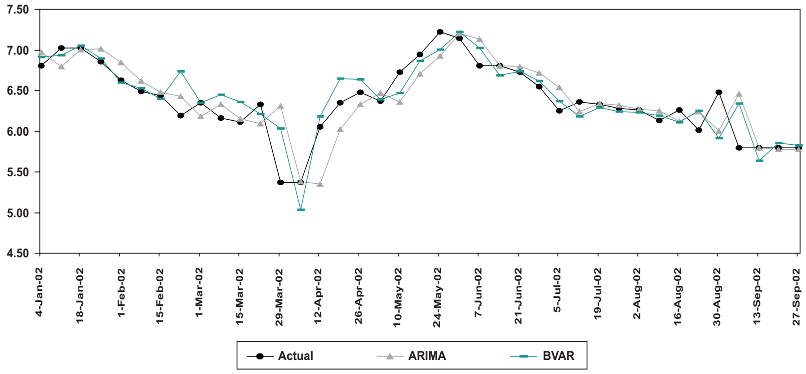


Fig 3.2C: 4-week-ahead Forecasts

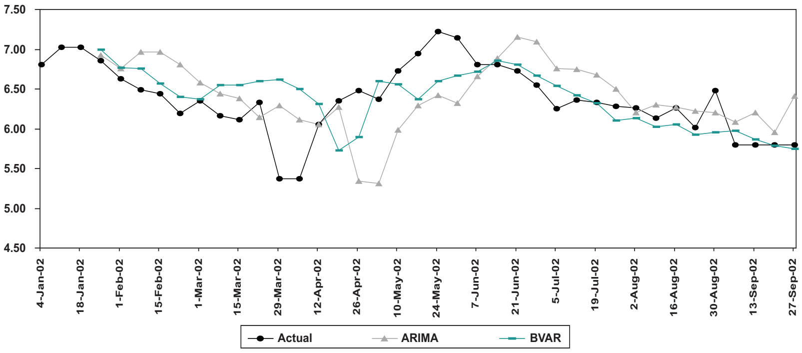
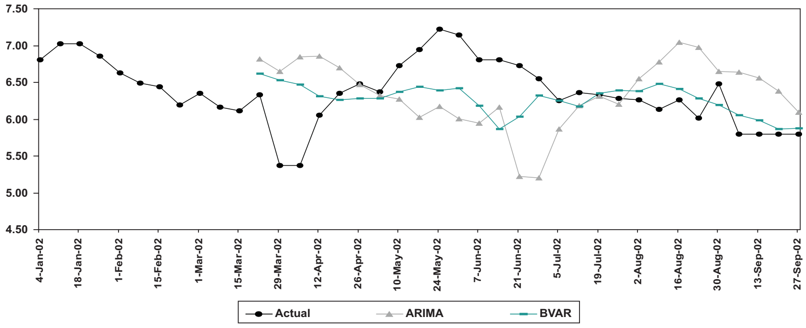


Fig 3.3C: 12-week-ahead Forecasts



GSec 5
Univariate Models

Fig 1.1D: 1-week-ahead Forecasts

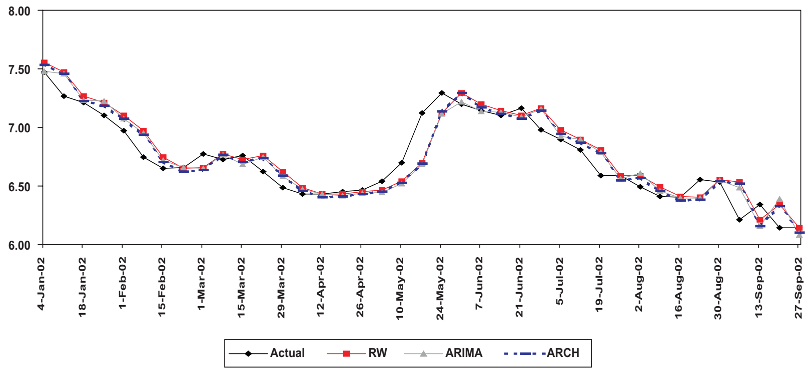


Fig 1.2D: 4-week-ahead Forecasts

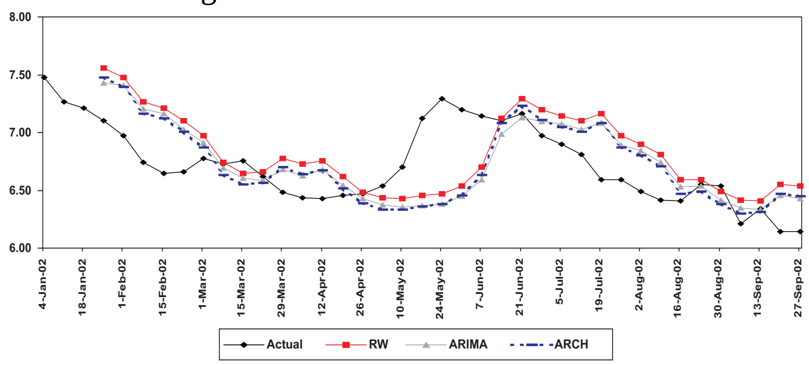
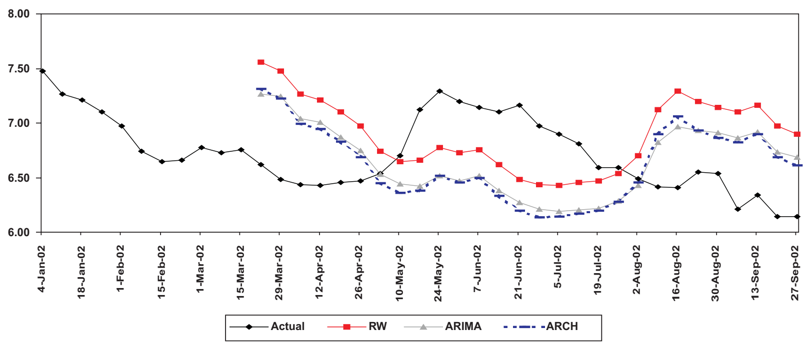


Fig 1.3D: 12-week-ahead Forecasts



GSec 5
Multivariate Models

Fig 2.1D: 1-week-ahead Forecasts

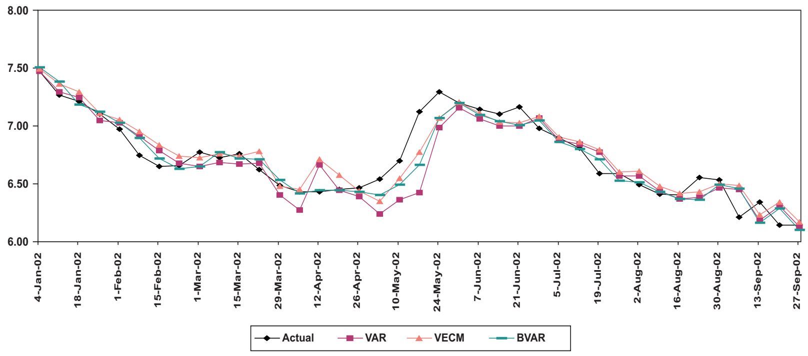


Fig 2.2D: 4-week-ahead Forecasts

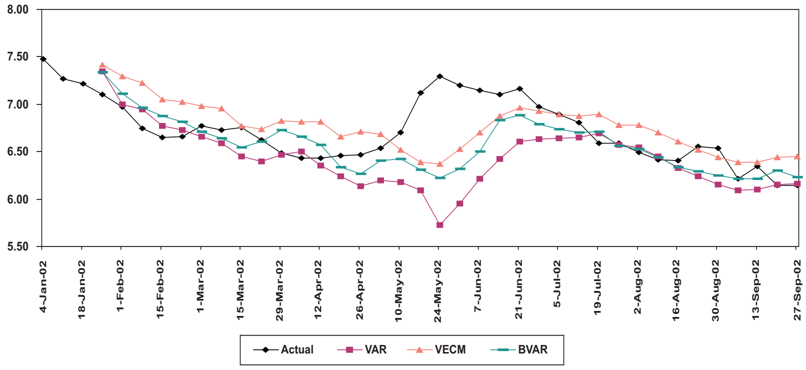
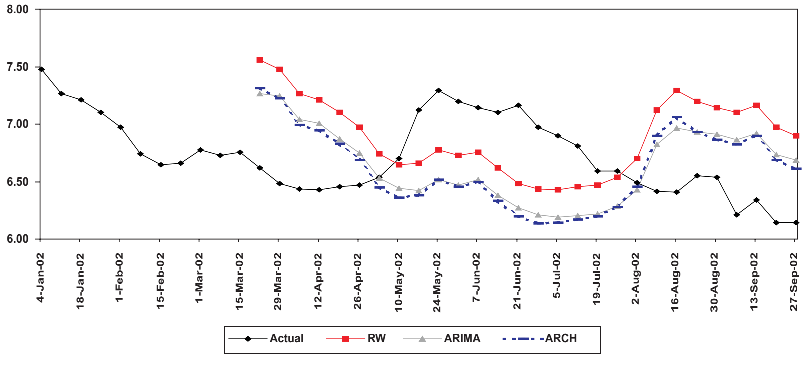


Fig 2.3D: 12-week-ahead Forecasts



GSec 5

"Best" Univariate vs. "Best" Multivariate Model

Fig 3.1D: 1-week-ahead Forecasts

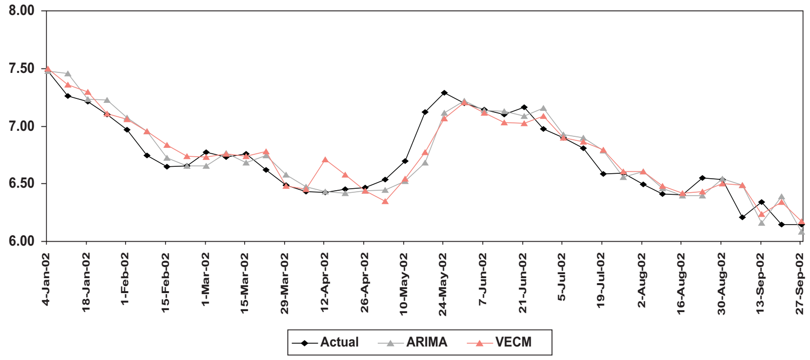


Fig 3.2D: 4-week-ahead Forecasts

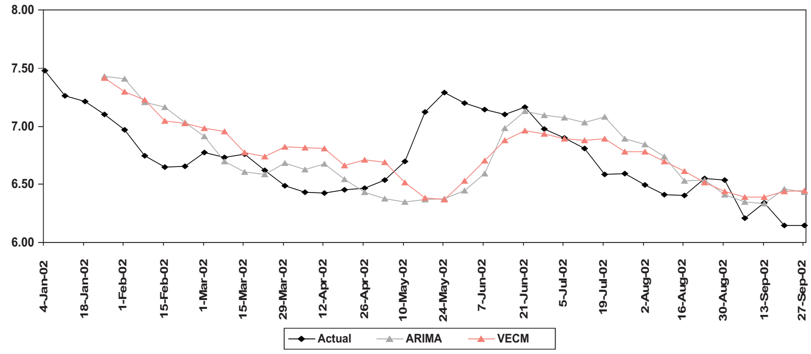
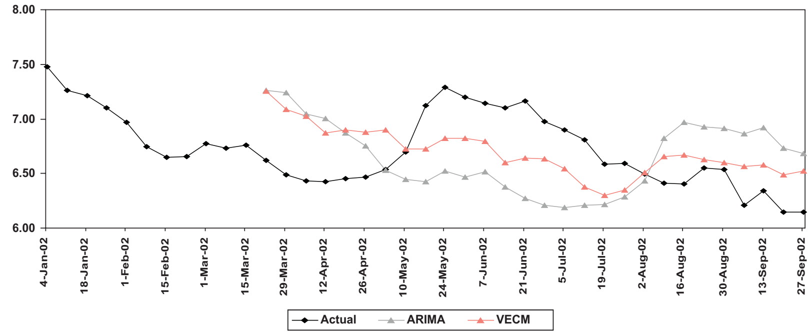


Fig 3.3D: 12-week-ahead Forecasts



GSec 10
Univariate Models

Fig 1.1E: 1-week-ahead Forecasts

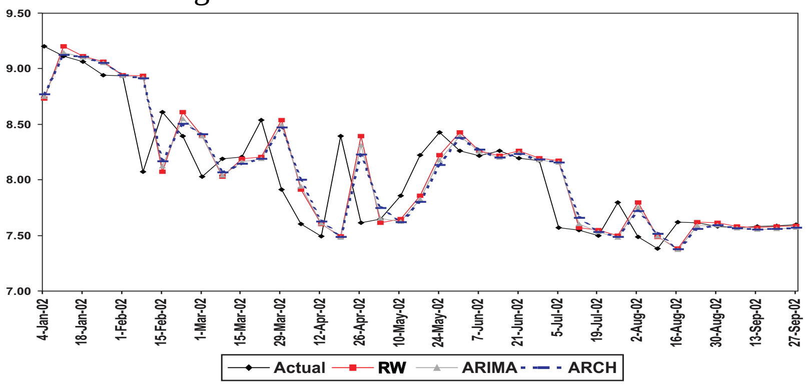


Fig 1.2E: 4-week-ahead Forecasts

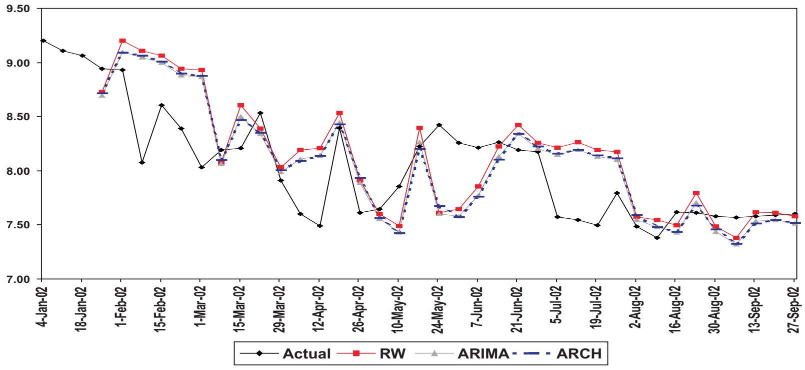
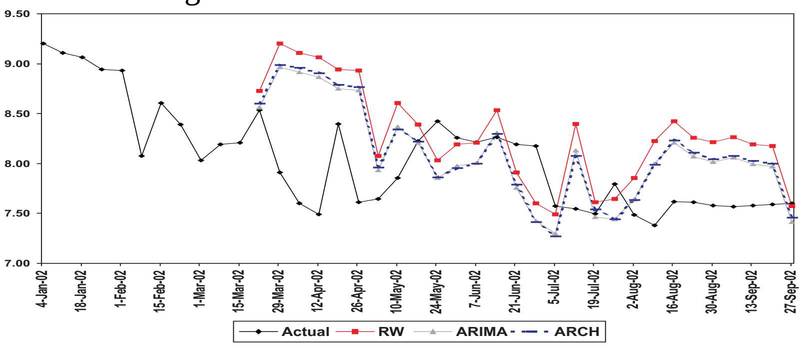


Fig 1.3E: 12-week-ahead Forecasts



GSec 10
Multivariate Models

Fig 2.1E: 1-week-ahead Forecasts

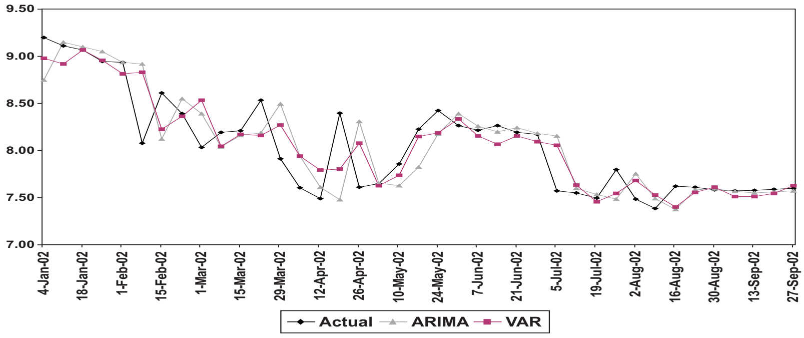


Fig 2.3E: 4-week-ahead Forecasts

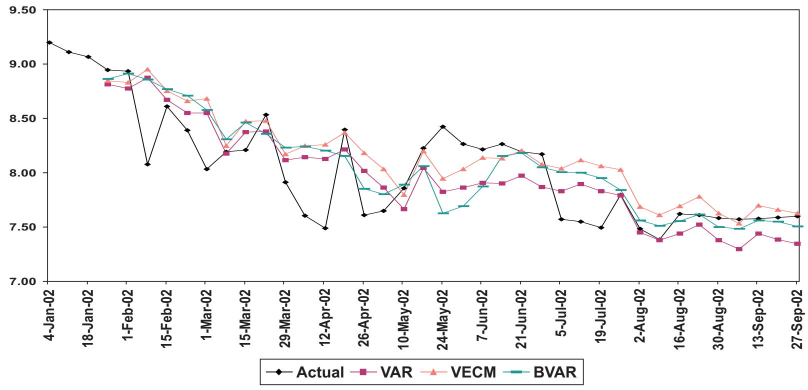
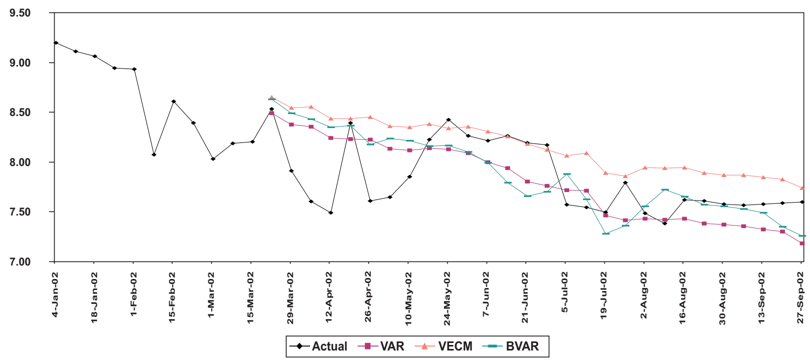


Fig 2.3E: 12-week-ahead Forecasts



GSec 10

"Best" Univariate vs. "Best" Multivariate Model

Fig 3.1E: 1-week-ahead Forecasts

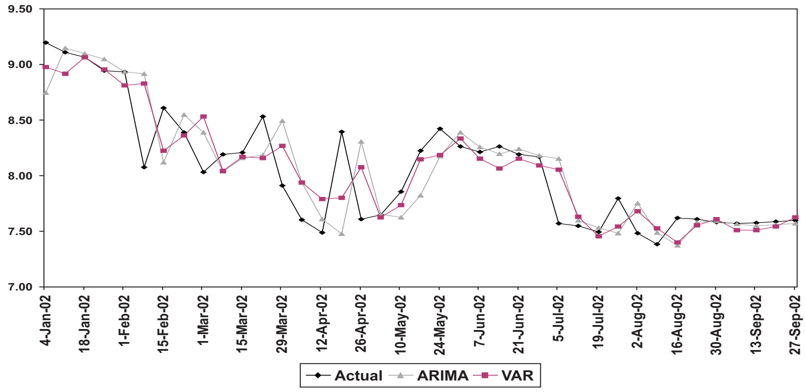


Fig 3.3E: 12-week-ahead Forecasts

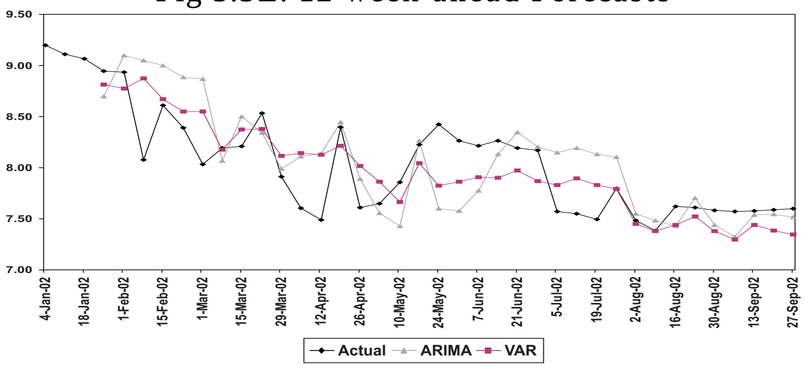
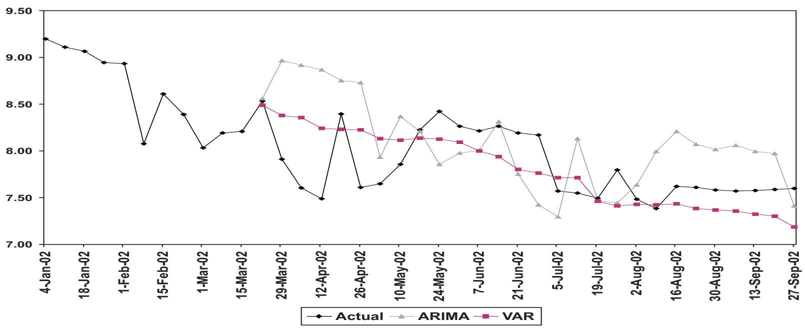
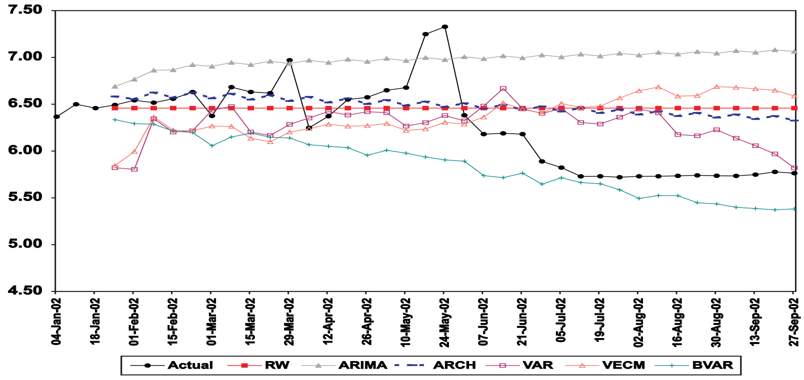


Fig 3.3E: 12-week-ahead Forecasts

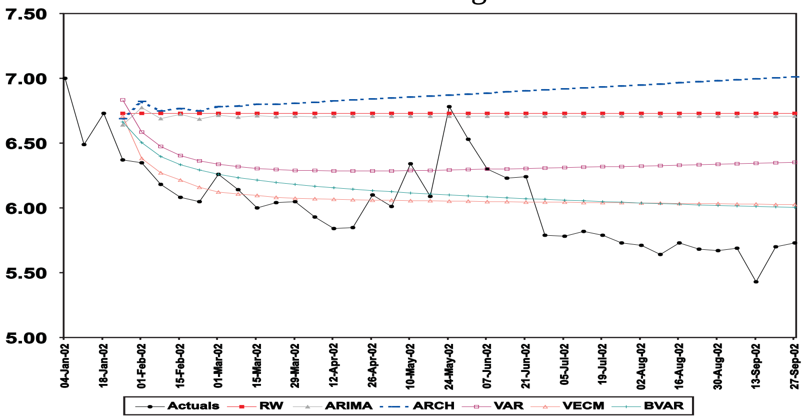


Out-of-sample forecasts: From 25th Jan to 27th Sep 2002

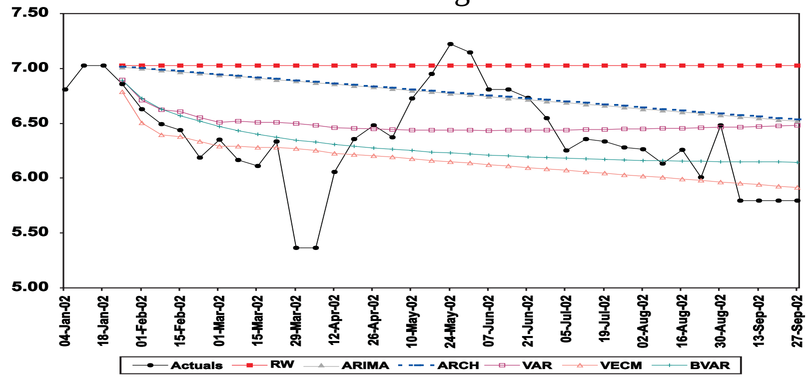
Call Money Rate Fig: 4A



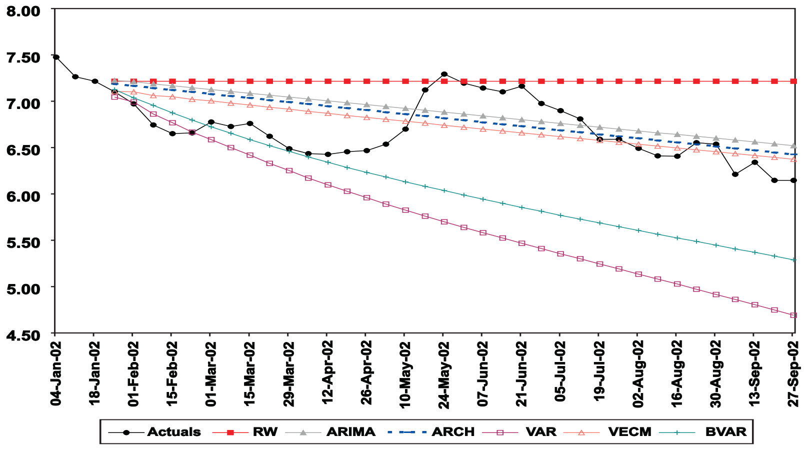
TB 15-91 Fig: 4B



GSec 1 Fig: 4C



GSec 5 Fig: 4D



GSec 10 Fig: 4E