Predicting Risk-Free Interest Rates

Insights from Autoregressive Modeling

ECON F342 : Applied Econometrics

Under the Supervision of

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Abstract

This paper tries to analyze whether a change in the current value of the weighted average yield (risk-free interest rate) is related to the past change in values of the risk-free interest rate. This was done using the autoregressive model with a lag length of 6 for time series analysis. The dataset for the research was taken from the biweekly data released by RBI. The results reveal that the risk-free interest rate is autocorrelated and influenced by past values. The analysis revealed that any change in the current value of the risk-free interest rate was significantly related to the change in the value of the risk-free rate over a fortnight, one month, two months, two and a half months, and three months. At the same time, it was found to be unrelated to any change one and a half months ago. The model is stationary, meaning it tends to return to its long-run average over time. The AR model can anticipate future risk-free interest rate values, although other factors should also be considered while making investing decisions.

Contents

1 Introduction

Around the world, one of the largest financial institutions are cooperative banks. Cooperative and commercial banks form an important part of the financial systems of many countries. Moreover, it has been observed that the share of these institutions has been increasing. When advanced and emerging economies are considered, the market share of cooperative banks in total banking sector assets has increased by more than 5 percent from the mid-1990s to 2004 (Hesse & Čihák, 2007).

In recent years, the relationship between interest rates and cash reserves held by institutions has been the subject of extensive study. The Reserve Bank of India (RBI) mandates that commercial and cooperative banks in India maintain a certain level of cash reserves as a liquidity requirement. The RBI also plays a crucial role in determining the country's interest rates. Changes in the cash reserve ratio (CRR), the proportion of deposits that banks are mandated to hold as cash reserves, can impact the amount of cash reserves held by banks, impacting interest rates.

Numerous studies have examined the connection between cash reserves and interest rates. Rudebusch & Wu (2008) discovered, for instance, that shifts in the Federal Reserve's holdings of government securities have a substantial effect on short-term interest rates. Similarly, Gurley & Shaw (1960) discovered that US banks with greater cash reserves tended to offer reduced deposit interest rates. In contrast, Caballero & Krishnamurthy (2003) discovered that an increase in cash reserves held by US institutions led to a rise in Treasury bond interest rates. According to a second study by Gertler & Karadi (2011), shifts in the cash reserves held by European banks substantially affected the term structure of interest rates.

In addition, India's banking system has faced difficulties recently due to increased nonperforming assets (NPAs) and liquidity issues. The Reserve Bank of India (RBI) has taken numerous steps to resolve these issues, including lowering interest rates and injecting liquidity into the system. The RBI introduced a new liquidity framework in 2020 with the intention of granting banks greater flexibility in managing their liquidity positions. The new framework permits banks to borrow funds at repo rates, the rates at which the RBI lends to banks and encourages banks to maintain a stable liquidity position.

Simply put, the connection between cash reserves and interest rates is intricate and ever-changing, and policymakers and market players would benefit greatly from a deeper comprehension of this connection. Using time series analysis, this research aims to evaluate the effect of bank cash reserves on the interest rates currently in place in India. Specifically, we will analyze the link between these two variables using data on cash reserves and interest rates from the Reserve Bank of India (RBI). This will give insights into the dynamics of interest rates in the Indian economy.

2 Literature Review

2.1 Paper 1

> "Performance and Challenges of Cooperative Banking Networks in European Countries: An Analysis"

By Poli (2019)

About the Paper

This study examines the impact of network models with varying levels of strategic integration on the performance of cooperative and commercial banks in European countries. It attempts to determine whether cooperative banks perform better than commercial banks statistically significant.

Use Case

This paper provides valuable insights into the research model and offers a deeper understanding of cooperative banking networks in India about their performance and challenges.

Methodology

Data is analysed quantitatively and qualitatively with a mixed-methods approach. The quantitative analysis uses panel data regression models, and the qualitative research involves interviews with cooperative bank managers. The study examines the performance of cooperative banks within a network framework.

Conclusion

The study finds that cooperative banking networks positively impact individual bank performance. However, it also identifies challenges cooperative banks face in maintaining network structures and managing conflicts within the network.

2.2 Paper 2

> "Urban Cooperative Banks and Sustainable Development in India"

By Badhe (2011)

About the Paper

This paper explores the importance of urban cooperative banks in promoting sustainable development in India. They must adhere to traditional banking practices and core values to prepare these banks for future crises. The paper highlights the necessity for further comparative studies to understand better the performance and impact of cooperative banks in turbulent market conditions.

Use Case

This paper provides valuable insights into the research model and offers a deeper understanding of the role of cooperative banks in promoting sustainable development in India.

Methodology

The study uses theoretical and empirical evidence to support the claim that cooperative banks have performed well in recent financial crises. Critical economic indicators and bank stability measures are used to conduct an empirical analysis. However, it is essential to note that a more definitive conclusion can only be reached after considering additional data.

Conclusion

The recent financial crisis makes it hard to draw definitive conclusions about cooperative banks' role in stabilising national economic systems. Cooperative banks are essential in promoting sustainable development and must maintain their core values and practices to thrive.

2.3 Paper 3

> "Relationship between Cooperative Banking and Rural Development in Punjab: A Canonical Correlation Approach"

By Sethi & Kumar (2013)

About the Paper

This paper uses canonical correlation analysis to examine the relationship between cooperative banking and rural development indicators in Punjab, India. The study assesses the role of cooperative banks in promoting rural development in the state.

Use case

This paper provides valuable insights into the research model and offers a deeper understanding of the relationship between cooperative banks and rural development in India, particularly in Punjab.

Methodology

The study employs a step-down canonical correlation analysis to guarantee comparability. Data from various sources, including the Reserve Bank of India and the Census of India, are used in the study.

Conclusion

The study finds that cooperative banking positively impacts rural development in Punjab, significantly promoting financial inclusion and economic growth in rural areas. The paper highlights the importance of cooperative banks in supporting sustainable rural development and calls for more research in this area.

2.4 Paper 4

"Velocity of Money Function for India: Analysis and Interpretations"

By Rami (2011)

About the Paper

This paper analyses Velocity of Money, a very well established macroeconomic concept.The heated debate between the monetarists and Keynesisans has been covered here where the stability of the aforementioned concept has been discussed in detail.

Use Case

This study has been diversified into three blocks: descriptive, explanatory and stochastic. Iyer (1970) saw a diminishing trend in velocity of M1 and M3, Saravane (1971) continued on a sectoral approach, and Vasudevan (1975) found instability.

Methodology

Here, the velocity function was reached using data for M3 velocity (V3) for the Indian context ranging in the time period between 1972-2004. Many combinations of the explanatory variables were tested, both including and excluding the dependent variables with their lags.

Conclusion

The inclusion of 'institutional' variables along with commonly taken variables like real income and interest rate, in the long run shows a reduction in real income elasticity of money demand.

2.5 Paper 5

"Interest Rate Determination: domestic and international"

By Dua & Goel (2021)

About the Paper

Analysis of the determinants of interest rates in India in the post-liberalisation period while considering every possible factors of economic impact such as domestic and international impacts has been done

Use Case

Provision of commercial paper rate, T-bills(both short term and long term) has been done in this paper.

Methodology

The results are in line with the interest rate trends and show that the capex, money supply, foreign interest rates as well as premium on forward will all have a dependent relationship. The impact of other internal and external factors is also visible.

Conclusion

The research comes to the conclusion that both internal and external variables affect the setting of interest rates. Results demonstrate that the domestic real interest rate is a Granger cause, with real money supply, real government spending, international interest rate, forward premium, and domestic inflation rate all playing a role. Inflation management, limiting government spending, managing currency depreciation, and upholding covered interest parity are some of the policy elements.

2.6 Paper 6

"Interest Rate Determination: domestic and international"

By Joshi (2004)

About the Paper

This paper shows how the use of indirect instruments by the Central banks help maintain the short-term policy rate, which impacts economic growth . Further, the volatility of the call money rate in India as well as its response time to regulatory changes has been analysed.

Use Case

In economies that rely primarily on indirect tools of monetary policy, the operation of the call money market and the conduct of monetary policy are closely connected.

Methodology

The study employs two common econometric techniques for model estimation: the ARCH-M[1,1] (Autoregressive Conditional Heteroscedasticity in Mean) model estimate and the Nelson Beveridge (NB) time series decomposition. While the later helps to distinguish between cyclical and permanent components in a time series, Engle's (1982) ARCH model gives the variance process an organised structure that makes it easier to understand and use in forecasting.

Conclusion

During the boom and bust periods, the Indian IPO market saw a sharp swing in volume and underpricing, indicating issuers were not dependent on initial returns. Affiliation with a particular industry has little impact on IPOs during the boom.

3 Data and Methodology

The dataset has been picked from the Money and Stock Component Sources section of the Time Series Publication from the RBI database. A multivariate time series modeling has been implemented here where the two variables considered are "Weighted Avg Yield (per cent) (Risk-Free Rate)" as the dependent variable and "Cash on Hand with Banks" as the independent variable are the two variables under consideration.

The time period considered is Sept 10, 2010 to Oct 7, 2022. The data is collected on a fortnightly basis.

The Weighted Average Yield (risk-free rate) is calculated by taking the weighted average of the yields of the securities in the portfolio of the banks, where the weights are the proportion of each security's contribution to the portfolio. The yield of each security is adjusted to reflect its risk level relative to the risk-free rate, typically by subtracting the risk-free rate from the security's yield.

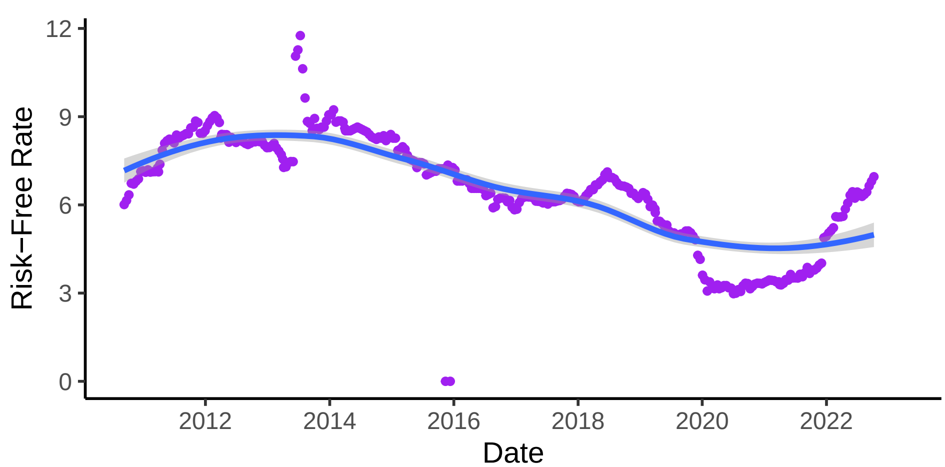


Figure 1: Weighted average yield (per cent) (risk-free rate)

The liquid cash that a Bank has at a given point in time is its Cash on Hand. It provides the bank with liquidity and flexibility in managing its daily transactions.

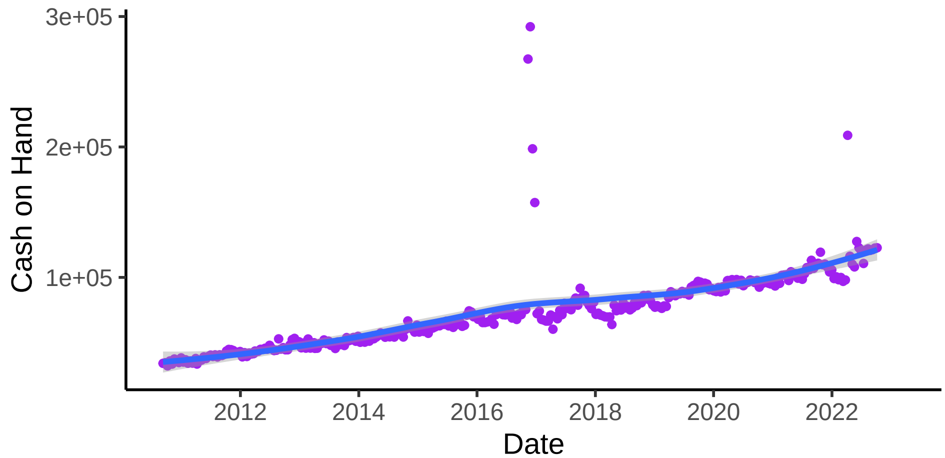


Figure 2: Cash on Hand with Banks

3.1 Methodology

The purpose of this model is to make the forecast about 'Weighted Average yield' based on its past values and their relationship with the past values of 'Cash on Hands with Banks'.

After accounting for the stationarity of the variable, we check for the type of model to be fitted, we run the AIC and the BIC tests and realise that the lag gives a minimum at lag 6 in both the cases, so we fit the ARDL(6,0) model. This leads to us considering this like an AR(6) model. Thereafter, the impact and significance of every other lag is analysed and interpreted.

4 Regression

Table 1: Lag order selection for an AR model

	1	2	3	4	5	6	7	8	9	10
AIC	769.6	575.9	550.7	455.2	426.8	-174.7	-159.9	-117.9	-77.9	-43.7
BIC	780.7	590.4	568.4	475.8	450.0	-149.1	-132.4	-89.0	-48.3	-14.4

From this, we assert that ARDL (6, 0) is the best parsimonious model.

Table 2: Fitted Model

term	estimate	std.error	statistic	p.value
(Intercept)	0.1602	0.1250	1.2819	0.2008
L(assgn3_rfr, 1:6)1	0.3009	0.0545	5.5184	0.0000

term	estimate	std.error	statistic	p.value
L(assgn3_rfr, 1:6)2	0.8197	0.0567	14.4625	0.0000
L(assgn3_rfr, 1:6)3	-0.1037	0.0690	-1.5021	0.1341
L(assgn3_rfr, 1:6)4	-0.4303	0.0690	-6.2345	0.0000
L(assgn3_rfr, 1:6)5	0.1247	0.0567	2.2011	0.0285
L(assgn3_rfr, 1:6)6	0.2643	0.0545	4.8510	0.0000

4.1 Diagnostics

Checking for autocorrelation by plotting acf

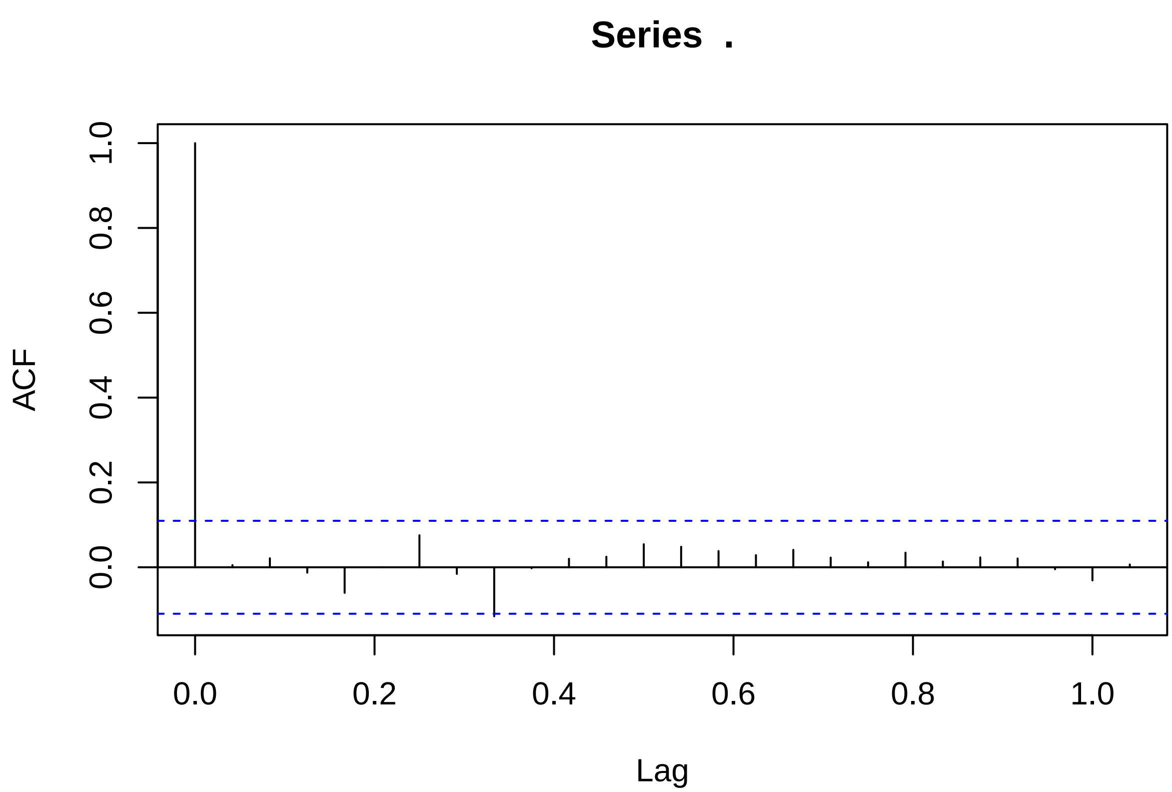


Figure 3: Residuals ACF Plot

Checking for autocorrelation using LM Test

The null hypothesis of the BG test has no autocorrelation, but here we reject the null hypothesis meaning that autocorrelation is present.

Table 3: Breusch-Godfrey test for the fitted ARDL (6, 0) model

Method	Statistic	Parameters	p-Value
1, F, 0	0.1182623	1, 312	0.7311585
1, F, NA	0.1244043	1, 311	0.7245448
6, Chisq, 0	9.35971	6	0.1543359
6, Chisq, NA	8.729323	6	0.1893827

Durbin-Watson test

Table 4: Results of the Durbin-Watson test

statistic	p.value	method	alternative
1.988652	0.4528315	Durbin-Watson test	true autocorrelation is greater than 0

The DW test is a statistical test to determine if the residuals of a regression model exhibit significant first-order autocorrelation. In this case, reject the null hypothesis that there is autocorrelation. Thus, our model does not have the issue of autocorrelation.

Both from the BG Test and DW Test, we infer that autocorrelation is present. This is because of the very high frequency dataset employed. Tofurther justify why ARDL (6, 0) is the best possible fit, we plotted residuals and correlograms. From plots of residuals, we infer that ARDL (6,0), ARDL (7,0) and ARDL (8,0) have very similar distribution of errors. From correlogram plots, keeping law of parsimony under consideration, we can infer that ARDL (6,0) has least possible autocorrelation, which is in line with the AIC/BIC outcome.

Error Residuals

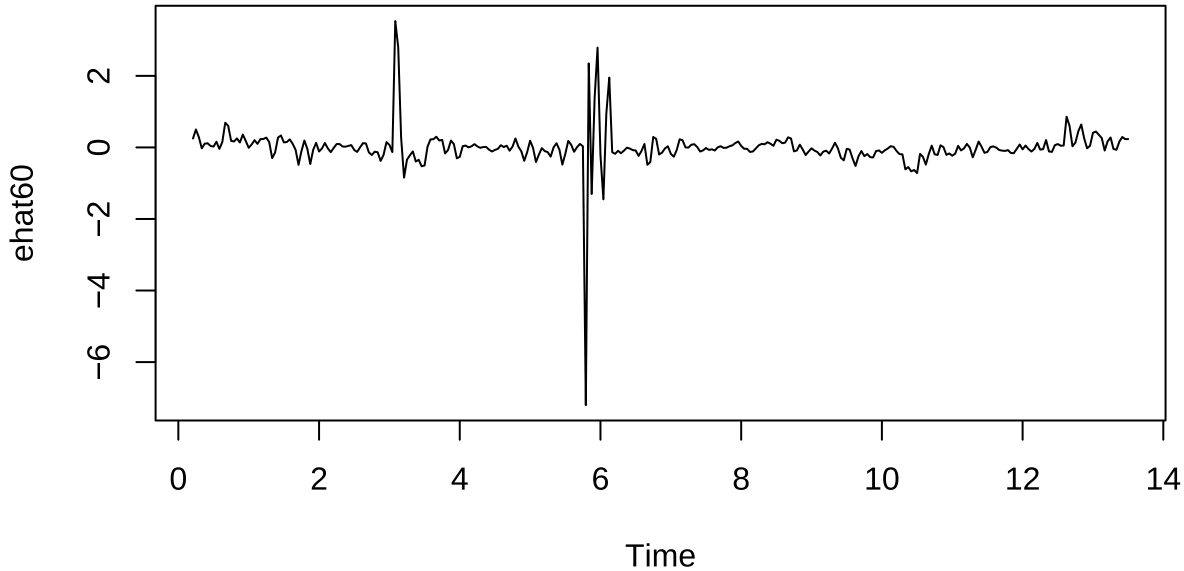


Figure 4: Error Residuals of ARDL(6, 0) model

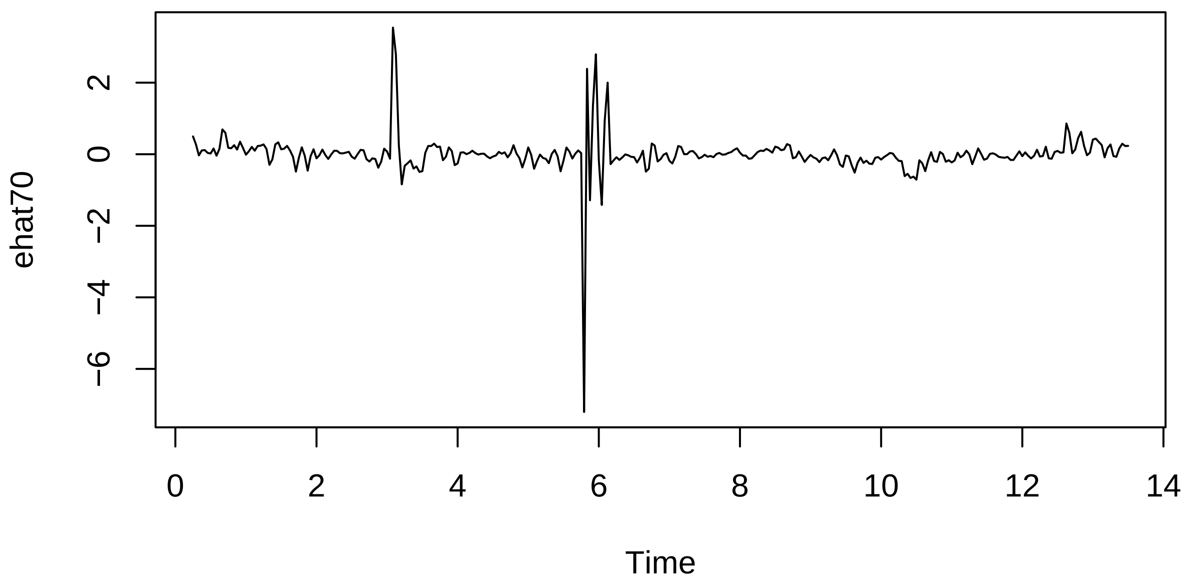


Figure 5: Error Residuals of ARDL(7, 0) model

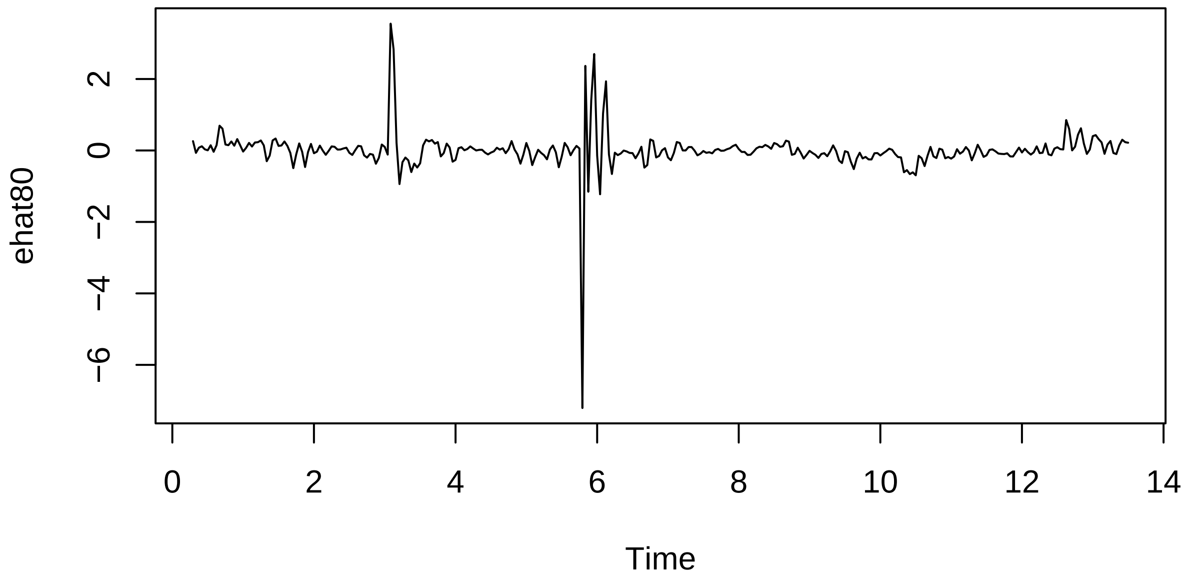
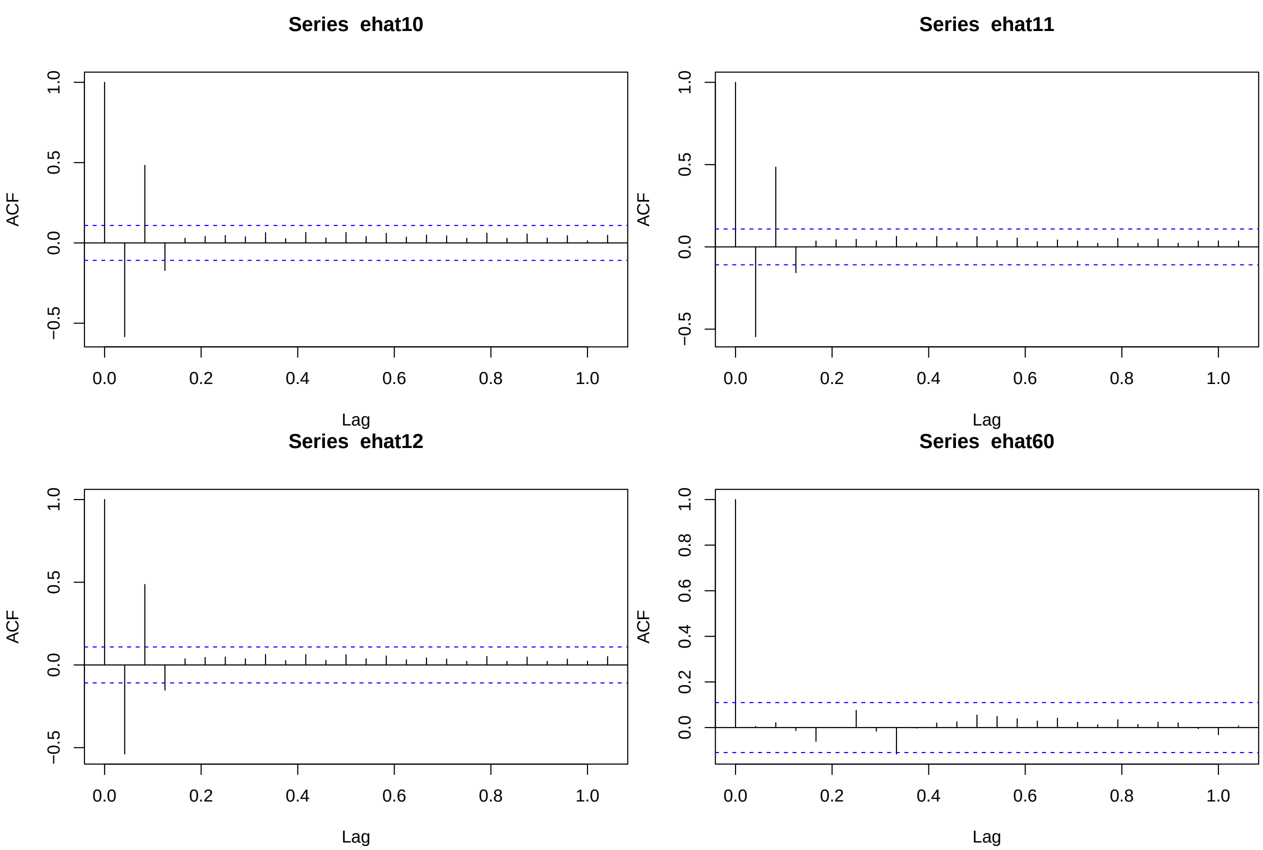


Figure 6: Error Residuals of ARDL(8, 0) model

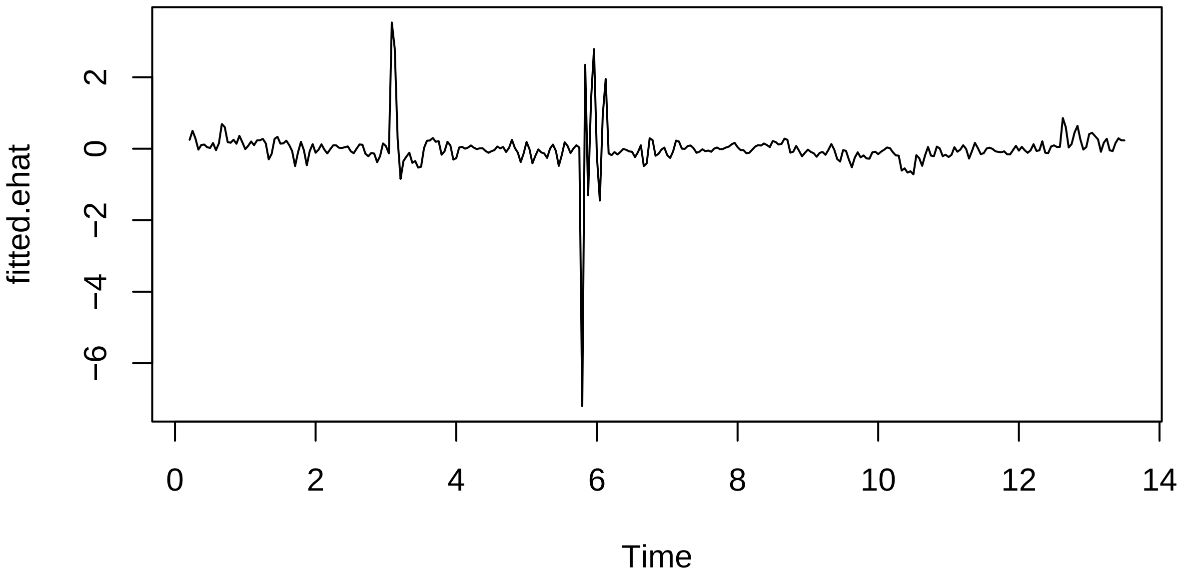
From the error residual ACF plots, we infer that ARDL (6,0), ARDL (7,0) and ARDL (8,0) have very similar distribution of errors

Correlogram Plots

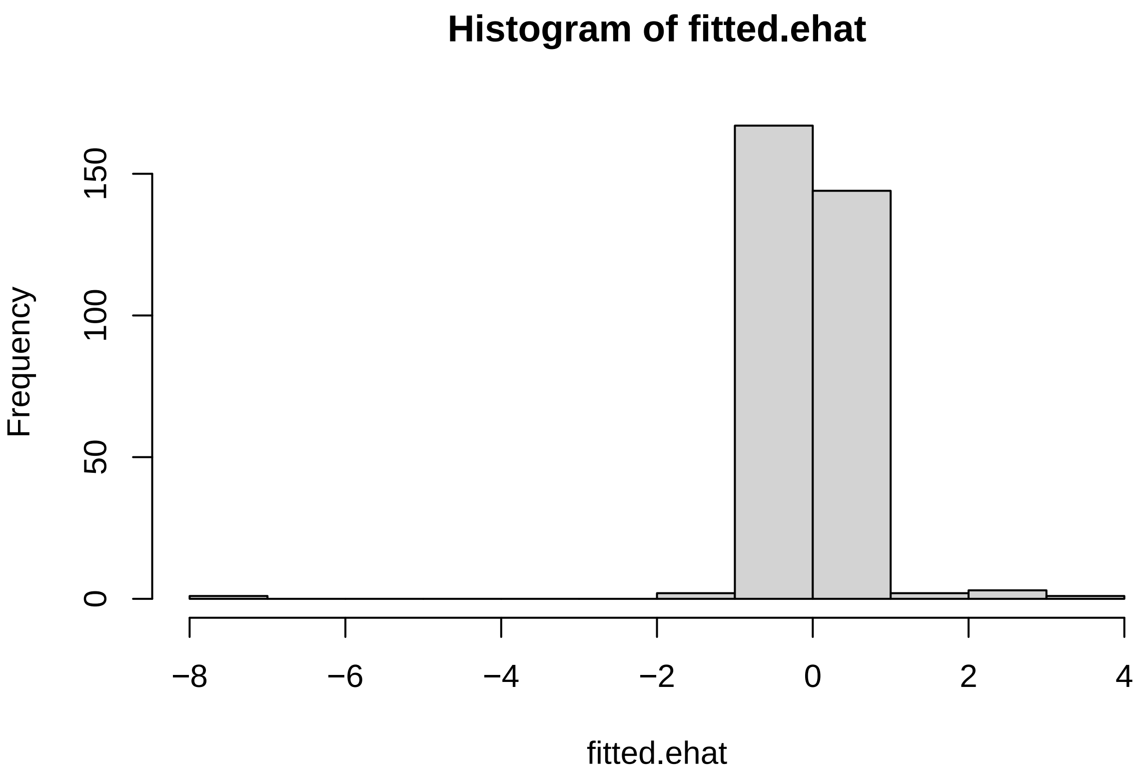


If we compare the correlogram plot we can infer that ARDL (6,0) has least possible autocorrelation, which is in line with the AIC/BIC outcome.

Checking for mean, variance, and normality of errors

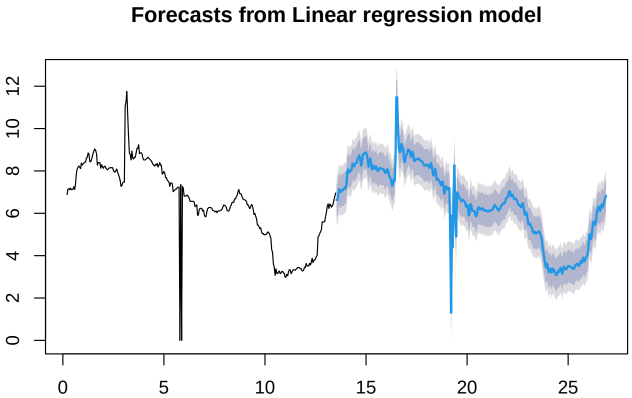


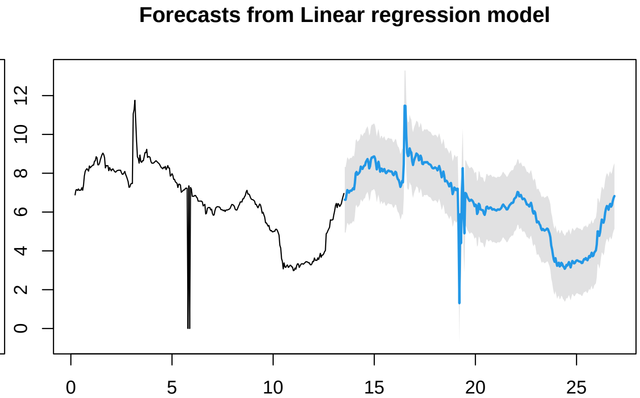
Mean comes out to be zero as seen from the plot, variance fairly remains constant.



From histogram, apart from a few outliers, we can clearly see that the distribution of errors is normal.

4.2 Forecasts





5 Conclusion

The AR model with lag length of 6 is able to explain 97.56% of the variation in the risk-free interest rate. The positive and statistically significant coefficients for lags 1, 2, 5, and 6 indicate that an increase in the risk-free interest rate in prior periods is connected with an increase in the risk-free interest rate in the current period. The extremely significant coefficient for lag 4 implies that an increase in the risk-free interest rate two months ago is connected with a fall in the risk-free interest rate in the current period. The non-statistically significant coefficient for lag 3 implies that the effect of the dependent variable on the present period one and a half months ago is weak and not statistically different from zero. The model suggests that the risk-free interest rate is autocorrelated, meaning that it is influenced by its own past values. The total multiplier also suggests that the model is stationary, meaning that it tends to return to its long-run average over time. The AR model can be used to anticipate future risk-free interest rate values. It is crucial to highlight, however, that the model is merely a statistical model and does not account for all of the factors that can influence the risk-free interest rate. As a result, the model should be utilised with caution, and other considerations should be considered while making investing decisions.

6 References

Badhe, M. D. A. (2011). Role of urban co-operative banks in sustainable development of india. *Research Student, Department of Economics, Solapur University, Solapur. Rani.*

Caballero, R. J., & Krishnamurthy, A. (2003). Excessive dollar debt: Financial development and underinsurance. *The Journal of Finance*, *58*(2), 867–893. Wiley Online Library.

Dua, P., & Goel, D. (2021). Determinants of inflation in india. *The Journal of Developing Areas*, *55*(2). Tennessee State University College of Business.

Gertler, M., & Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, *58*(1), 17–34. Retrieved from https://www.sciencedirect.com/science/article/pii/S0304393210001261

Gurley, J. G., & Shaw, E. S. (1960). Money in a theory of finance (washington, dc: Brookings institution, 1960). *GurleyMoney in a Theory of Finance*.

Hesse, H., & Čihák, M. (2007). Cooperative banks and financial stability. IMF working paper.

Joshi, H. (2004). The interbank money market in india: Evidence on volatility, efficacy of regulatory initiatives and implications for interest rate targeting. *RESERVE BANK OF INDIA*, 17.

Poli, F. (2019). *Co-operative banking networks in europe: Models and performance*. Springer Nature.

Rami, G. (2011). Velocity of money function for india: Analysis and interpretations. *Available at SSRN 1783473*.

Rudebusch, G. D., & Wu, T. (2008). A macro-finance model of the term structure, monetary policy and the economy. *The Economic Journal*, *118*(530), 906–926. Oxford University Press Oxford, UK.

Sethi, A. S., & Kumar, S. (2013). Co-operative banking and rural development in punjab–an examination of interdependencies through canonical correlation approach. *Journal of Income & Wealth (The)*, *35*(2), 11–22. Indian Association for Research in National Income & Wealth.