Time Series Analysis of Inflation and RBI Policy Rates

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Abstract

This paper examines the relationship between inflation and RBI rate policies during normal period and bank crisis period. For this, the paper has taken WPI's (Whole Sale Price Index) as inflation rate and under RBI rate policies bank rate, CRR, SLR rates has taken for the period of 1991 to 2017. Empirical evidence obtained from time series regression model, the model accuracy tested by Co-integration and Error Correction Models using for the period of annual data from RBI. The result shows that, the model is good fitted for data and it considered as good regression model. Bank_ rate, CRR and SLR have significant influences on inflation during normal period as well as crisis period. The trace statistical test Eigen value of co-integration and ECM model proves that all variables have long run relationship with each other.

Key words: Inflation, RBI Rate Policies, co-integration, CRR, SLR, Monetary Policies.

Introduction

The Reserve Bank of India acts as the Central Bank of a country. It was established in 1935 on April 1st. The RBI performs various functions. Along with monetary management it performs on foreign exchange, banking operations, research and developmental works on problems of economy. Apart from these functions, the major objective of the RBI is to stabilize the economy in terms of prices through monetary policy. Monetary policies are of two types quantitative or general or indirect and qualitative or selective or direct. The quantitative monetary policy includes Bank rate policies, which includes Bank Rate, Cash Reserve Ratio and Statutory Liquidity Ratio, Repo Rate and Reverse Repo Rate, Marginal Standing facility Rate. Regarding this, the Preamble to the RBI Act, 1934 clearly says that relating to objective "To regulate the issues of banking notes and the keeping of reserve with review to securing monetary stability in India and generally to operate the currency and credit system of the country to its advantages".

The present paper examines the responsiveness of prices or inflation rate to a change in the RBI Policy rates. This paper considered inflation rates in terms of Whole Sale Price Index's, which measure the price of representative basket of wholesale goods it includes 690 articles of primary commodity, fuel and power and manufactured items. In India till 2012 the WPI index has been used for measure inflation rate. When

Raghuram Rajan was Governor of RBI there has been change of thought. The central bank started to look at Consumer Price Index (CPI) to measure inflation rate. But the present paper sticks on to WPI to measure inflation rate due to technical problem of data periods. CPI urban and rural data available since 2012, but this paper has taken data for analysis purpose since 1991.

This paper considered Bank Rate, CRR and SLR under RBI Rate policy to measure inflation. Bank rate means, the rate of interest charged by the RBI on the loans granted to commercial Banks. Commercial Banks borrow funds from the central bank and lend the money to their customers at a higher interest rate and thus making profits. In this way bank rate is an important tool to control liquidity. Bank rate is usually higher than the Repo rate. When bank rate is increased by RBI, the borrowing costs of the banks increase which, in turn, reduce the supply of money in the market bank. Additionally, when the unemployment rate within a country increases, the central bank decreases the bank rate so that individuals can get loan at a reduced rate. This will help in two ways. Firstly, it will help the banking sector to function smoothly and maintain the currency supply within a country for economic growth.

CRR (cash Reserve Ratio) it is the amount of fund that the commercial banks has to keep with the central bank. Adjusting the rate of CRR by central bank will change the total money supply in economy. The chain of affect to curb inflation is, bank will increase CRR in case of inflation, and fewer amounts of funds will be available to the banks for credit creation and the total money supplied in the economy will decrease.

SLR (Statutory Liquidity Ratio) it is the amount of liquidity that the commercial banks have to keep with themselves. Adjusting the rate of SLR by the Central Bank will change the total money supplied in the economy. Increased SLR reduces the amount of funds that the bank can use to give credit. The effect to curb inflation is, in case of inflation central bank will increase SLR, and fewer amounts of funds will be available to the banks for credit creation. Further result that the total money supplied in the economy will decrease.

The present paper has taken data from 1991 to 2017 for the normal period, however these years includes crisis period also (2008 to 2012 and 2013). This paper examines the relationship between inflation and RBI Policy rate through construct an inflation model by time series data. Regarding this, the present paper has five sections. In first section the paper has been discussed theory and specification of the paper. The second section of the paper discussed literature reviews and objectives, followed, methodology and fourth part of the paper discussed Results and Discussions. And last part of the paper followed by conclusion.

I. Theory and Specification

In developing economy like India the inflation models are set under two categories one is monetarist and another is structuralist. The present paper does not going to discuss with structuralist theory because it considers Sectoral prices. Moreover the structuralist theory is not related to present paper. The monetarist explanation is based on quantity theory of money (Fisher MV=PT). The classical theory of interest rate and inflation discussed the supply side factors and demand side factors. The loanable fund theory explains the rate of interest is the price of credit which is determined by the demand and supply for loanable funds.

Keynes explains demand for money is determined by interest rate. Natural and market rate of interest by Wicksell discussed the rate of interest and prices in his book "Interest and prices". Hence, present paper is based on monetary aspects, interest rates and monetary policy of RBI.

II. Literature Reviews

Enormous study have forecasted inflation model by using bank rates.

One of the papers from **Hafer et.al (1990)** provided international evidence using monthly Euro rates and the consumer price index for the period of 1967-86. Results indicate that the time series forecasts of inflation have equal or lower forecast errors. The other approach by **Fama and Gibbons(1975, 1977, 1982, 1984)** extracts from observed nominal interest rates based on a Univariate time series modeling of the real interest rate. They find that the interest rate model yields inflation forecasts with a lower error variance.

Actually, Univariate models to be used for comparing alternative forecasting methods.

Akhtaruzzama (2005) identifies the variables possibly generating inflation in Bangladesh used Co-integration and ECM. The results are interest rate, money supply and level of the depreciation of exchange rate explains inflation.

The following approach by **Javed et.al (2011),** a rise in the interest rate will affects the price of final goods because a cost of borrowing involved. This happens because a rise in interest rate leads to a decline in the consumer spending in developed countries which results in lower general prices.

The model developed by **Callen and Chang (1999)**, they estimated series of bivariate VAR's to measure inflation. They study found that money supply (M1 and M3) and the price of primary products and price of manufacturing sector which influences the inflation in India.

Ahmed (1991), found that Gross National Product (GNP), growth rate of imports and growth in ratio of M1, M2 are important variable in determining inflation rate. Because of variation in RBI bank rate policies the M1 and M2 ratio has been made changed.

Ahmed and Ali(199) and Kemal(2006) found evidence in favor of quantity theory influenced the factors rate of interest and velocity of money. Followed by **Dhaka (1993)** founds that the money supply M1, interest rates, and import product prices are important variables to determine the inflation.

Many of the research papers have been using different variables and methodology in forecasting inflation. For this purpose many authors have used Univariate mode (ARIMA and ARCH) models, VAR model, Co-integration and ECM models. Comparison of forecast efficiency of different types of models has been made in many studies.

The above different studies conclude that time series models are superior then economic models. Hence, present paper has been construct model forecasting purpose and for this, time series model has been used.

2.1 Objectives of the paper

Based on the above literature reviews the present paper has been framed following two objectives.

- To check the regression model is Good fitted or not.

- To check long term relationship between economic variables (i.e., dependent and independent variables) by Johansen Co-integration and ECM model.

III. Methodology

This paper is based on secondary data collection, which is obtained by the Hand Book of RBI since 1991 to 2017. For the analysis purpose the paper has built a time series regression model on Inflation and Bank Rate Policies. To become a good regression model there should be few criteria; the present model in this paper fulfilled all criteria's. Such has, residual autocorrelation, for this, the paper has been used correlation LM test. To test Heteroscadasticity the paper has used Brush Pegan Godfrey Test. For normal distribution of residuals, the paper has been used JB test. Unit Root Test is used to check whether the data has Stationary or not. The Johansen co-integration analysis has been attempted to determine the long term relationship between economic variables.

IV. Results and Discussion

To examine the relationship between Inflation and RBI Rate Polices, the paper has taken Inflation as dependent variable and Bank rate, CRR and SLR are as independent variables. All the variables those are used in analysis are already in percentage form. For this purpose, the paper has not used log[1] formation of data. This paper has constructed the following multiple Regression Model.

$$WPI_t=\beta_0 + \beta_1 BR_t + \beta_2 CRR_t + \beta_3 SLR_t + e_t \ldots$$ Equation 1

WPI- whole sale price Index (Inflation)
BR- Bank Rate
CRR- Cash Reserve Ratio
SLR –Statutory Liquidity Ratio
e-error term.
t-time Periods

The table 1 has explained the results of regression model 1 after run the Regression model by using Eviews 9 software.

Table 1Time Series Multiple Regression Model

Dependent Variable: WPI				
Method: Least Squares				
Date: 09/13/18 Time: 07:38				
Sample: 1991 -2017				
Included observations: 40				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-5.863835	2.139000	-2.741390	**0.0095**
BANK_RATE	-0.076577	0.274538	0.278929	**0.0819**
CRR	-0.456945	0.212265	-2.152707	**0.0381**

[1] The raw data should be converted in to log form before analysis if it is not in percentage form, the concept log is used to convert raw data into percentage form.

SLR	-0.558651	0.104854	5.327885	**0.0000**
R-squared	**0.591014**	Mean dependent var		5.694250
Adjusted R-squared	0.459432	S.D. dependent var		2.554650
S.E. of regression	1.878264	Akaike info criterion		4.193213
Sum squared resid	127.0035	Schwarz criterion		4.362101
Log likelihood	-79.86425	Hannan-Quinn criter.		4.254277
F-statistic	**12.04876**	**Durbin-Watson stat**		**1.523125**
Prob(F-statistic)	**0.000013**			

Source: Author calculation based on secondary data.

The table 1 explained the following results. To become good regression model there should be fulfill few criteria. The first criterion is R square. The R^2 value should be greater than 60% is desirable. In our model the R square value is 59.01%, it explain the fluctuations of Inflation rate which can be explained by three variables jointly. So, one can say that 59.01% of fluctuation of inflation is explained by Bank Rate, CRR and SLR. Rest of the fluctuation (40%) is explained by other factors which are not included in the model.

The second criterion is '**t'statistic,** which is explained the significant of individual variables to explain inflation in the model. As per the guidelines, at least half of the independent variables should be significance at less than 5% level to explain dependent variable. In present model the two variables are significance at 5%level among three variables. The variable 'Bank rate' is significance at 10% level; the probability value of Bank Rate is 8.1% which is less than at 10% level. The 'p' value of CRR is 3.8% which is significance at 5% level and the 'p' value of SLR is (0.000) which is significance at less than 1% level. The fourth criterion is all the independent variables should be jointly significant to explain inflation. The F statistics is used to explain joint significance of variables. In this model the 'p' value of F statistics is (0.000) significant at less than 1% level. Meaning that, bank rate, CRR, and SLR are influenced jointly on inflation. The fifth criterion is sign of coefficient. It should follow either economic theory or expectation or intuitions. Present model is constructed based on economic theory. The following points are explained how model to be based on economic theory.

- In the present model the intercept value 'C', which has negative sign this indicates that, if the values of Bank rate, CRR and SLR were zero, the average level of inflation would be decreased by 5.8%. In economic theory the contraction or dear monetary policy influences on decreasing the inflation rate. But in this case the C is meaningless.
- If bank rate goes up by 1% on average inflation rate would goes down by 7.6% (the coefficient value is -0.0765) on average provided other independent variables are constant.
- Inflation rate increased by 45% (the coefficient value is -0.456945)on average, if CRR level goes down by1% on average or if CRR level goes up by 1% on average the inflation rate would reduced by 45%on average provided other independent variable are fixed.

- If SLR rate goes up by 1% on average the inflation rate would reduced by 55% on average provided other independent variable are constant.

The sixth criterion is to test autocorrelation and heteroscadasticity problems in residuals. In this case the model assumes that null hypothesis is no serial autocorrelation in the model. Breush –Godfrey serial correlation lm test proves that p value is more than 5% and R square is 63% (0.63020), 13 lags to be taken. The study concludes that the residual term does not have any serial correlation. So the H_0 is accepted.

Table 2 Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.335790	Prob. F(13,23)	0.2630
Obs*R-squared	17.20813	Prob. Chi-Square(13)	0.1900
R-squared	0.630203		

Source: Author calculation based on secondary data.

To check heteroscadasticity problem, the model assumes that H_0 has no heteroscadasticity which is tested by Brush Pegan Godfrey Test. The p value is greater than 5% level meaning that we cannot reject null hypothesis. Hence the model does not have heteroscadasticity problem which explained by table 3, the H_0 is accepted.

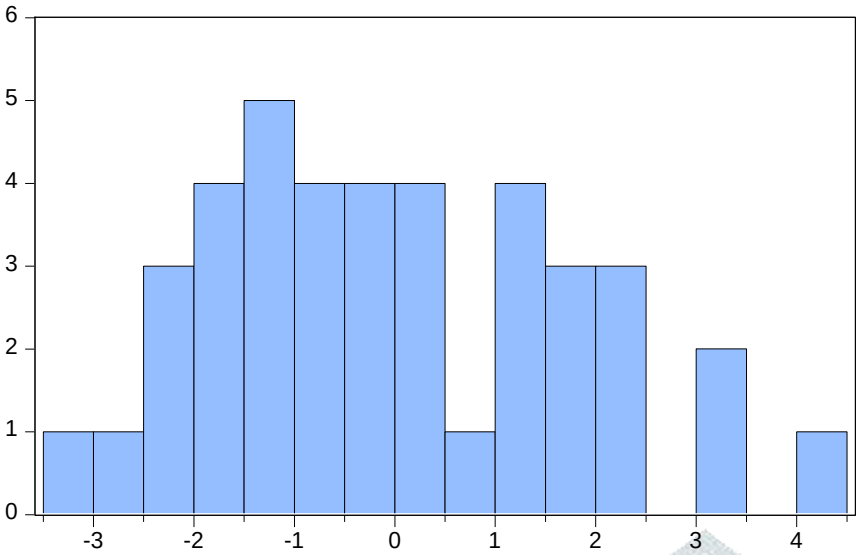
Table 3 Breusch-Godfrey Serial Correlation LM Test for Heteroscadasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	2.247592	Prob. F(3,36)	0.0994
Obs*R-squared	6.310098	Prob. Chi-Square(3)	0.0975
Scaled explained SS	3.476142	Prob. Chi-Square(3)	0.3239
R square	0.557752		

Source: Author calculation based on secondary data.

The last criterion is residual should be distributed normally, it is important to check normality of residuals in the model from Jarque Bera Statistics. In chart 1 is shown that JB statistics test.

Chart 1 Jarque Bera Statistics test



Source: Author calculation based on secondary data.

The p value is of JB test is greater than 5% level, which shows that, the residuals are distributed. To become good regression model the residual should be normally distributed.

4.1 Unit Root test

Unit root test is conducted to check whether each variable of the data has stationary character or not. The table 4 shows that the result of unit root test at level and first difference with 9 lags (by default) by using Augmented Dickey –Fuller (ADF) tests which includes trend and constant. The null hypothesis of the model assumes that, H_0 has a unit root. Hence unit root cannot be rejected at the 5% (alpha value is 0.05) significance level for any variable. At level constant ADF test has conducted, the results are the p value is more than 5% level, so we cannot reject the null hypothesis. Meaning that, the entire 4 variables sample data has non stationary. The results suggest that the macroeconomic variables have a stochastic trend. Since no variable is stationary and have a unit root at the 5% level significance in ADF test at level. The next step is to test the variables for second unit root by conducting the first difference level.

Table 4 Results of Unit Root Test

Variables	Augmented Dicky Fuller Test P value and Durbin Watson value at level	Augmented Dicky Fuller P value and Durbin Watson value at first difference
WPI	0.0608 (2.041362)	0.000* (1.962653)
Bank_rate	0.2774 (2.150974)	0.000* (1.9831752)
CRR	0.4505 (1.651815)	0.0000* (1.971308)
SLR	0.2330 (1.90889)	0.000* (1.988217)

*stationary at 5% significance level and Durbin Watson statistics in Parentheses

The results of first difference unit root test suggest that, reject the null hypothesis for all the variables; all variables are stationary at 5 percent significance level. The values of Durbin Watson statistics for all variables are close two. Therefore, the data has converted into stationary from non stationary.

4.2 Johansen Co-integration Test

In order to determine the long run relationship of economic variable or these economic variables are co-integrated or not in long run, it is important to run the Johansen Co-integration test. The result of Johansen Co-integration test will determine whether unrestricted VAR or Vector Error Correction should be used or not.

This test between WPI (inflation), Bank_rate, SLR and CRR are undertaken with the condition on the hypothesis of a unit root. The data is converted into stationary at first difference level constant (intercept). The result of the Johansen co-integration is shown in the above table 5. From the trace statistics and Eigen value one can conclude that the variables have co-integrated or not.

In present paper the results of Johansen co-integration shown that from the trace statistic value which is 88.33% it is highly significant at less than 1% probability value. Similarly Eigenvalue test also showed maximum Eigenvalue statistics 59.41% which is highly significant with less than 1% p value.

Table 5 Results of Johansen Co-integration test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		**Trace**	**0.05**	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.594100	88.30908	47.85613	0.0000
At most 1 *	0.535327	54.94810	29.79707	0.0000
At most 2 *	0.344620	26.59053	15.49471	0.0007
At most 3 *	0.256304	10.95653	3.841466	0.0009
Trace test indicates 4 cointegratingeqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.594100	33.36098	27.58434	0.0081
At most 1 *	0.535327	28.35757	21.13162	0.0040
At most 2 *	0.344620	15.63400	14.26460	0.0302
At most 3 *	0.256304	10.95653	3.841466	0.0009

Source: author calculation based on secondary data.

Therefore both tests are confirmed that all the economic variables are co-integrated. Since the variables are co-integrated than we can go for error correction model (ECM).

4.2 Unrestricted Error Correction Model

Error correction model is a model it helps us to find out there short term and long term relationship of economic variables provided the variables are co-integrated. To know whether the model is spurious or not we consider R square value and Durbin Watson Statistics value considered. When R square is greater than DW statistics then model is spurious. If R square is less than DW statistics then the model is not a spurious. Table 6 has shown the results of ECM model. For this, the paper has constructed following model.

$$\mathbf{DWPI = \beta_1 + \beta_2 D*bank\text{-}rate + \beta_3 D*CRR + \beta_4 *SLR + \beta_5 u_{t-1} + v} \ldots\ldots \text{equation 2}$$

DWPI- First difference of intercept - inflation or stationary inflation

Dbank rate First difference of intercept - bank rate or stationary bank rate

DSLR First difference of intercept – SLR or stationary SLR

DCRR First difference of intercept - CRR or stationary CRR

U_{t-1} One period lag residual of model.

V Error term

This U_{t-1} is an error correction term that guides variables of the system to restore back to equilibrium or it corrects disequilibrium.

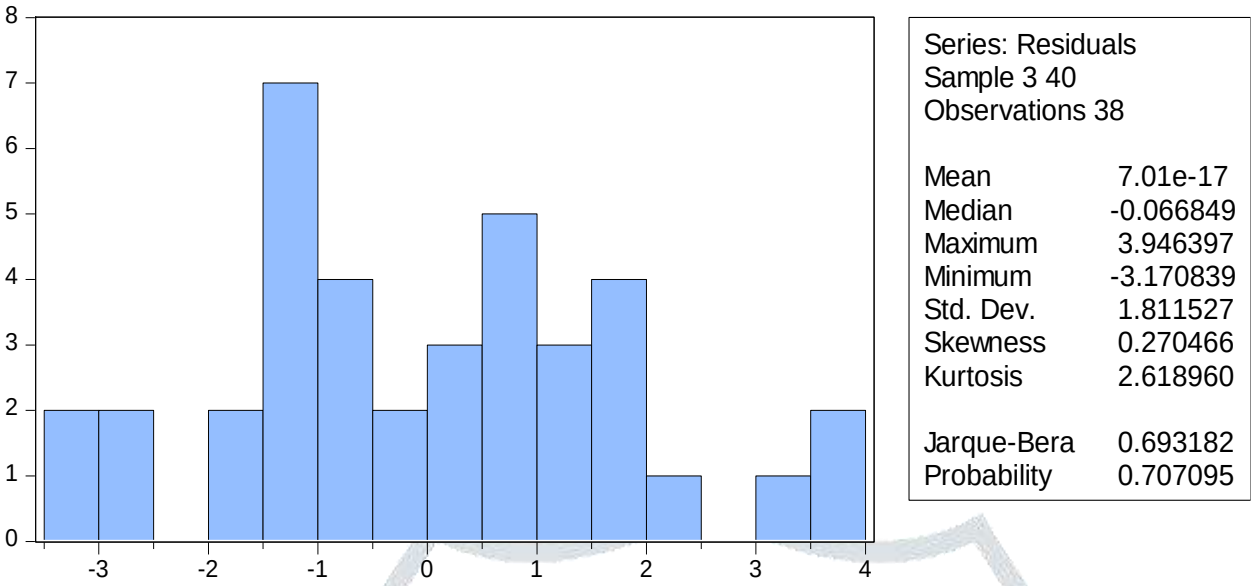
Table 6 Results sheet of Error Correction Model

Dependent Variable: DWPI				
Method: Least Squares				
Date: 09/23/18 Time: 02:08				
Sample (adjusted): 3 40				
Included observations: 38 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.131401	0.336772	-0.390178	0.6989
DSLR	0.128249	0.235710	0.544095	0.5900
DCRR	-0.160388	0.377012	-0.425418	0.6733
DBANK_RATE	0.270534	0.295492	0.915539	0.3666
U1(-1)	**-0.450918**	**0.152514**	**-2.956559**	**0.0057**
R-squared	**0.241482**	Mean dependent var		-0.169737
Adjusted R-squared	0.149540	S.D. dependent var		2.079993
S.E. of regression	1.918178	Akaike info criterion		4.262707
Sum squared resid	121.4204	Schwarz criterion		4.478179
Log likelihood	-75.99144	Hannan-Quinn criter.		4.339371
F-statistic	2.626466	**Durbin-Watson stat**		**2.094588**
Prob(F-statistic)	0.052126			

Source: author calculation based on secondary data.

As per the guidelines R^2 <DW, conclude that the model is not spurious. In table 6 shown that the DW stat value is 209% or near to two the R^2 is 24%, hence the model is not spurious.(24<209). Sign of u(-1) has negative sign, it gives validity of the model. And p value is significance at less than 5% level (0.0057). Thus, the present model has long term relationship between variables. The serial correlation in residual is more than 5% level so we reject the null hypothesis and accept the alternative hypothesis. Meaning that, there is no serial correlation between residual terms. And heteroscadasticity test is done in the model by Breush Pagon godfray test, it shows that no heteroscadasticity problem in the model. Last one normal distribution of residuals, the following chart 2 had shown Jarque bera test results. As per the JB value is more than 5%, the residuals of the present model is normally distributed.

Chart 2 Jarque Bera Box



Source: author calculation based on secondary data.

V. Conclusion

This paper empirically explores the inflation and RBI rate policies from 1991 to 2017. It proves that RBI rate policies affect the inflation during both crisis period and normal periods. The study derived its conclusions by adopting time series approach. The empirical evidence demonstrates that the relationship between inflation and RBI rate policies have long term relations as it shown by ECM model. This model suggests that the RBI rate policies affect inflation in long run. However this model is free from spurious therefore the ECM model is used for forecasting.

Since researcher has taken year on year data, 2018 is yet to complete. So the researcher proposes to test the relationship between Inflation rate and RBI policy rates in present banking crisis.

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