3 Chapter

Research Methodology of the Study

3.1 Introduction

Secondary data has been used as per the demand of the study since 1991-91 to 2014-15 at macro level. Methodology has been opted as per the problems and objectives of study. The study has been done to discuss and analyses two objectives which are: first, to find out trend and pattern of macroeconomic variables which include goal variables and operating instruments. Second, to analysis the monetary policy reaction functions in India after liberalization. For better analyses year wise data of different variables has been taken for the study. To fulfill first objective growth rate and natural growth methods has been used and for second objective OLS has been used. Hodrick-Prescott filter statistical technique and production function have used for estimation of variables used in study. Due to unavailability of same base year data splicing method has used.

3.2 Trend and pattern of macroeconomic variables

To find out trend and pattern of macroeconomics variable with natural log of some variables (output gap, inflation gap, money supply and nominal GVA) and growth rate of real GVA, GVA Deflator inflation. To calculate growth rate following formula has used:

$$GR= (V_t-V_{t-1})/V_{t-1} \times 100$$

Here, V_t and V_{t-1} refer to present year and past year value, GR represents growth rate.

3.3 Study of monetary policy reaction function

In this objective of study monetary policy reaction function has analyzed which also refers to monetary policy rule. It has done through OLS method. Before using OLS technique stationary and long run relationship have checked through unit root and co integration test respectively. If a variable is stationary at level in unit root test it means that it represents long run relationship. If it does not happen then variable's stationarity has been checked at 1st difference and to check long run relationship co integration has used. Taylor and McCallum rule have applied to check fluctuations in macroeconomic variables through OLS and GMM model.

3.4 Techniques used in the study

Following techniques have used in analysis:

- Hodrick-Prescott filter statistical technique and Production Function
- Unit root test
- Co integration test
- Taylor and McCallum rule and Taylor-McCallum hybrid rule
- Ordinary Least Square method (OLS) and GMM.

Identical base year is very necessary for study in time series analysis because if data is not of same year then the analysis would bias, inefficient, and unreliable. Every time, it is not possible for researcher to get data of same base year when analysis is of long run. So splicing is a method to change and construct base year.

3.4.1 Hodrick-Prescott filter[1] statistical technique and Production Function

Hodrick and Prescott in 1997 propounded the popular statistical filter known as Hodrick Prescott (HP) filter to estimate potential output. The main advantage of HP filter over any liner regression method is that it delivers estimates based on weighted moving average of the observations close to the commencement and end of the sample period. By minimizing function potential output (y*) can be obtained with subject to a penalty that constrains the second difference of potential output for the sample T, which is as following:

$$\text{Min} \sum_{t=1}^{T}(y_t - y^*)^2 + \gamma \sum_{t=2}^{T-1}[(y_{t-1}^* - y^*) - (y^* - y_{t-1}^*)]^2$$

[1] Hodrick, R. and Prescott, E. C. (1997). Postwar U.S. Business Cycles: An Empirical Investigation, *Journal of Money, Credit, and Banking*, 29(1): 116.

Where, γ is a weighting parameter which regulates the trend's degree of smoothness relative to output gap. Lower value of represents the trend closeness

to actual output & high value of γ represents that trend output that converges to linear trend. Hence, γ also decides that how actual output can bring towards near to potential output. As per literature has concerned and through practice for yearly data, study used the value of γ equal to 100.

3.4.2 Unit Root Test[2]

Unit root test is a test of stationary which has been became popular from last few years. It checks whether a time series variable is non-stationary and holds a unit root. The steps of unit root test are as follows:

Step 1: Test z_t to see if it is stationary. If yes, then $z_t \sim I(0)$; if no, then $z_t \sim I(n)$; n>0.

Step 2: Take first differences of z_t as $\Delta z_t = z_t - z_{t-1}$, and test Δz_t to see if it is stationary. yes. Then $z_t \sim I(1)$; n>0

Step 3: Take second difference of z_t as $\Delta^2 z_t = \Delta z_t - \Delta z_{t-1}$, & test $\Delta^2 z_t$ to see if is stationary. If yes, $z_t \sim I(2)$; if no, then $z_t \sim I(2)$; n>0 and so on until it is found to be stationary, and finally $z_t \sim I(3)$; which means that z_t need to be differenced three times to be become stationary.

3.4.2.1 The Augmented Dickley-Fuller (ADF) test

Dickey and Fuller (1979, 1981) propounded a technique to test for non-stationarity. Their test based on the fact that testing for non-stationary is equivalent to testing for the existence of a unit root test. By suggesting an augmented version of the test which comprises extra lagged terms of the dependent variable in order to eliminate autocorrelation they extended their test technique, Dickley-Fuller test is estimated in three different forms, that is, under three different null hypotheses.

[2]Asterious, D., & Hall, S. (2011). *Applied econometrics* (second ed.). Palgrave macmillan.

z_t is a random walk $\Delta z_t = \delta z_{t-1} + u_t$ (1)

z_t is a random walk with drift $\Delta z_t = \beta_1 + \delta z_{t-1} + u_t$ (2)

z_t is a random walk with drift around a deterministic trend $\Delta z_t = \beta_1 + \beta_2 t + \delta z_{t-1} + u_t$ (3)

Here, z is observed time series, t is the time index, and β_1 is the intercept constant known as drift. δ represents coefficient presenting process root, β_2 is a coefficient on a time trend and u_t is an independent identical distributes residual term.

The Phillips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests have been also used for unit root test.

3.4.3 Co-Integration test

If the variables are non-stationary, they go father to be co-integration test to avoid a spurious regression and long run equilibrium relationship among the variables, then it could be used in the regression model as without the bearing to a spurious regression. There are number of test for co-integration such as the co-integration Durbin-Waston test, Enger-Granger co-integration test and Jonson co-integration test. In this study, there are used Jonson test for the co-integration among the variables in empirical analysis due to the advantage that this test well use for multiple variable analysis.`

In this study the numbers of co-integrations are predicted with the help of the Trace & statistics. It developed by Jonson. Co-integration analysis is used for stationary long run, or equilibrium relationship among the variables and to avoid a b spurious regression.

3.4.4 Taylor and McCallum rule and Taylor and McCallum Hybrid rule

Close and open economy of Taylor and McCallum rule has been taken in the study with backward – forward looking regime. 24 years data have been taken .Central bank has been tried to minimize loss function through weighted of inflation rate and output gap. Taylor rule works as an instrument to the optimization problem which provides the solution of loss function to the central bank in terms of inflation and output gap (Woodforld.2001).

Taylor and McCallum rule of closed economy are as follow:

In his work, Taylor (1993) estimates a rule for conducting monetary policy, to describe the fund rate's behavior as short term nominal interest rate:

$$i^*_t = \pi_t + r^* + \alpha(\pi_t - \pi^*_t) + \beta(y_t) \qquad (4)$$

In this above equation, i^*_t the target short-run nominal interest rate (i.e. the fund rate in US), π_t is the rate of inflation as calculated by the GVA deflator, r^* is the equilibrium real interest rate, y_t[3] is the real output gap, i.e. it is deviation of real GVA from their potential GVA.

The central bank should consider to changes in nominal interest rate which is response of deviation between actual inflation rate and target inflation and also the deviation between actual Gross Value Added (GVA) and potential GVA. i.e. nominal interest rate in short run is function of the output gap and inflation gap.

Equation (4) is converted to easy form:

$$i^*_t = \lambda + \mu\pi_t + \beta y_t \qquad (5)$$

Where, $\mu = r^*_t - \alpha\pi^*_t$ and $\beta = 1 + \alpha$. In this equation, both π_τ and α should be in plus (weight of $\alpha = \beta = 0.5$, Taylor's 1993 paper has proposed).

McCallum (1987, 1988,) also put a rule to describe the central bank's bahaviour towards the fluctuations of macroeconomic variable, through growth of money supply as an instrument. McCallum rule can be described as:

[3] Natural logarithm has been considered to estimate output gap.

$$\Delta b = \Delta x^* + \Delta v_t + \theta(\Delta x^* - \Delta x_{t-1}) \quad (6)$$

Here Δb represents growth rate of money supply (lnb_t-lnb_{t-1}), Δx^* is target growth rate money supply (Δx^* is constant and equals to the sum of targeted inflation and long run growth rate of average real GVA), Δv_t shows growth rate of velocity of money (McCallum used the average of lagged sixteen quarter) and ($\Delta x^* - \Delta x_{t-1}$) represents nominal GVA gap (deviation between target nominal GVA and actual nominal GVA)

Taylor(2001) and McCallum rule(2000) of Open economy

From equation (4) and (6) by converting closed economy into open economy the equation will be as follow

$$i^*_t = \pi_t + r^* + \alpha(\pi_t - \pi^*_t) + \beta(y_t) + e_t \quad (7)$$

Equation 9 represents the modified Taylor rule which is for open economy. Modified rule of McCallum for open economy is as follow:

$$\Delta b = \Delta x^* + \Delta v_t + \theta(\Delta x^* - \Delta x_{t-1}) + e_t \quad (8)$$

Here e_t is taken as a symbol of exchange rate which was firstly introduced by Ball (1998) in both rules.

3.4.5 Hybrid McCallum-Taylor Rule

Hybrid policy rule is combination of Taylor and McCallum rule. In Hybrid McCallum-Taylor Rule, Taylor rule's policy instrument variable, such as interest rate, is taken as dependent variable and McCallum rule's target variables are taken as independent variables. On other hand McCallum rule's policy instrument variable is taken as dependent variable and Taylor rule's target variables are taken as independent variable. This equation is known as Hybrid McCallum-Taylor Rule.

Hybrid McCallum-Taylor Rule in closed economy

$$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^* y_t + \varepsilon_t \quad (9)$$

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + \varepsilon_t \quad (10)$$

Hybrid McCallum-Taylor Rule in open economy

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + c_4^* \Delta e_t + \varepsilon_t \quad (11)$$

$$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^*(yt) + d_3^* e_t + \varepsilon_t \quad (12)$$

3.4.6 Contemporaneous/Backward-looking Version

By adding error term in above equations we get transformed as follows

Taylor Rule:

$$i_t = a_0 + a_1^* \pi_t + a_2^* y_t + \varepsilon_t$$

McCallum Rule

$$\Delta b = b_1^* \Delta x^* + b_2^* \Delta v_t + b_3^* (\Delta x^* - \Delta x_{t-1}) + \varepsilon_t$$

Hybrid McCallum-Taylor Rule

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + \varepsilon_t$$

Hybrid McCallum-Taylor Rule

$$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^* y_t + \varepsilon_t$$

Open economy

Taylor Rule:

$$i_t = a_0 + a_1^*(\pi_t - \pi^*_t) + a_2^* y_t + a_3^* e_t + \varepsilon_t$$

McCallum Rule

$$\Delta b = b_1^* \Delta x^* + b_2^* \Delta v_t + b_3^* (\Delta x^* \square \Delta x_{t-1}) + b_4^* e_t + \varepsilon_t$$

Hybrid McCallum-Taylor Rule

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + c_4^* \Delta e_t + \varepsilon_t$$

Hybrid McCallum-Taylor Rule

$$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^*(yt) + d_3^* e_t + \varepsilon_t$$

3.4.7 OLS/GMM method

Carl Friedrich Gauss propounded the method of ordinary least squares. It is one of the most popular methods of regression analysis with some attractive statistical properties. It is the method to estimate unknown parameter and minimize residual. It is important to use OLS that there should be not the presence of perfect multicollinearity, heteroscedasticity and autocorrelation.

3.5 Variables used in the study

To fulfill the objectives of study various variables are used. which are real GVA growth, real output gap, potential GVA, GVA deflator as an inflation rate, target GVA deflator, inflation gap, nominal GVA, Reserve money, trade oriented REER (Real Effective Exchange Rate) of 36 currency, money velocity, target nominal GVA, nominal GVA growth rate and target nominal GVA growth rate. These all variables have found out through various formulas and study which are as follows:

3.5.1 Real output gap

It is an economic measure of difference between the actual output and potential output.

Real output gap =Actual Output – Potential Output

$$\text{Real output gap} = (y^t - y^*) \times 100$$

Here y^t and y^* are in natural logarithm.

3.5.2 Potential GVA, Target GVA deflator and target nominal GVA

These all have calculated by using HP filter statistical technique.

3.5.3 GVA Deflator

GVA deflator can be calculated through following formula:

$$\text{GVA deflator} = \frac{Nominal\ GVA}{Real\ GVA} \times 100$$

Note: The GVA deflator is always equals to 100 in the base year.

Inflation rate can be calculated by using GVA deflator through following formula:

$$\text{Inflation Rate} = \frac{GVA\ deflator\ of\ current\ year - GVA\ defaltor\ of\ previous\ year}{GVA\ deflator\ of\ previous\ year} \times 100$$

3.5.4 Inflation Gap

Inflation gap is the difference between actual and potential inflation. It can be calculated through following formula:

$$\text{Inflation gap} = (\text{In}\ \pi - \text{In}\ \pi^*) \times 100$$

Here, ln equal to natural log

3.5.5 Base Money Growth Rate (Δb)

Base money growth rate gets the form of natural log difference. $\Delta b = \ln b_1 - \ln b_{t-1}$. Reserve money or high-powered money refers to the money made available the monetary authority of a country. In India, the Reserve Bank of India and the Government of India produce high-powered money. The Reserve Bank of India calls high-powered money as monetary base or reserve money. High- powered money includes (i) currency with the public (C) + (ii) cash reserves of banks (R) + (iii) other deposits with the Reserve Bank of India (OD).

3.5.6 Money Velocity

Money velocity can be calculated by using fisher equation (MV =PT), Here velocity is V, i. e. it can be written as V = PT/M, and PT can be termed as nominal GDP. Therefore the velocity of money can be written as

$$\text{Velocity of money (V)} = \frac{Nominal\ GDP}{M}$$

Here money is money reserve.

Few variables like real GVA growth, growth rate of money supply, nominal GVA growth rate and target nominal GVA growth rate have calculated through percentage growth method which has already explained above.

Few variables like nominal GVA, money supply (m_1 and m_3) and trade oriented REER real effective exchange rate are taken from official websites.

3.5.7 Nominal output gap

The nominal output gap is equal to the change target of nominal GVA minus growth rate of nominal GVA at first lag.

$$\text{Nominal output gap} = \Delta x^* - \Delta x_{t-1}$$

3.6 Data source of the study

To fulfill the objectives of the study secondary data has used from various source like Reserve Bank of India (RBI) database, International Monetary Fund (IMF), Central Statistical Organization (CSO) database.