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RESEARCH ARTICLE

THRESHOLD RATE OF INFLATION AND ECONOMIC GROWTH: EMPIRICAL EVIDENCE FROM INDIA.

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Abstract

During the last decade of the twentieth century, economics witnessed a revival of interest in the determinants of the rate of long-run growth. The monetary and fiscal policy variables play a predominant role in determining the growth of the economy. The major challenge for the monetary authorities is to keep the inflation at moderate levels. Which rate of inflation is tolerable for the Indian economy is the most debatable topic among the policy makers and researchers. In this study an attempt has been made to estimate the growth model using different levels of threshold inflation rates between the time period 1971-2012 using annual data. The Ordinary Least Squares (OLS) regression results show that the threshold rate of 6% is the acceptable inflation rate for the Indian economy. Alongside, through Granger causality we found that fiscal deficit (FD), Investment (I) and agriculture growth rate are major determinants of the growth in the gross domestic product (GDP).

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Introduction:-

Economic growth is a term used to indicate the increase in total gross domestic product (GDP). It is often measured as the rate of change of (GDP). Economic growth refers only to the quantity of goods and services produced; it says nothing about the way in which they are produced. Economic development, a related term, refers to change in the position of the economy and how goods and services are produced; positive economic growth involves the introduction of more efficient or "productive" technologies or forms of social organization. Economic growth can either be positive or negative. Negative growth can also be referred to by saying that the economy is shrinking. Negative growth is associated with economic recession and economic depression.

Gross national product (GNP) is sometimes used as an alternative measure to gross domestic product. In order to compare multiple countries, the statistics may be quoted in a single currency, based on either prevailing exchange rates or purchasing power parity. Then, in order to compare countries of different population sizes, the per capita figure is quoted. To compensate for changes in the value of money (inflation or deflation) the GDP or GNP is usually given in "real" or inflation adjusted, terms rather than the actual money figure compiled in a given year, which is called the nominal or current figure.

Economists draw a distinction between short-term economic stabilization and long- term economic growth. The topic of economic growth is primarily concerned with the long run economic progress. The short-run variation of

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economic growth is termed as the business cycle. The long-run path of economic growth is desirable (essential) to any economy, an increase in GDP of a country is generally taken as an increase in the standard of living of its inhabitants. Over long periods of time, even small rates of annual growth can have large effects through compounding. All the economic theories beginning with classical, Keynesian, Neoclassical and endogenous growth models have emphasized the importance of growth. Every country takes its major economic decisions in order to achieve a better growth of its economy. The first and foremost thing that any country needs to have is the capital which is the fuel for the economic activity. To reap the real benefits from the capital, country must have favourable macroeconomic conditions which are conducive for the efficient functioning of economy. One such important macroeconomic variable is inflation. Inflation is a growing concern for all the developing, developed and under developed countries. Inflation can bedefined as the persistent rise in the general price level of goods and services in an economy over a period of time. Increase in inflation rate reduces the purchasing power of people. Every sector of the economy prefers a low inflation in order to have a better performance.

Several studies have been made to address the problems related to the construction and calculation of inflation using different indices, the effects of inflation on the economic growth, etc... David Hume in the 18th century, including Keynes made out the relationship between inflation and rapid economic development. The similitude objective of the monetaryauthority is to achieve the higher economic growth with long run price stability. This objective is also known as long run neutrality of money. There is always a trade-off between the inflation and economic growth. The higher inflation rates hamper the state both economically and socially. Hence, the monetary authority always has to take some stringent measures to have a check on inflation.

Active management of capital flows, an effective sterilization of foreign exchange market interventions and a judicious use of the menu of monetary instruments is reflected in the final objectives of inflation and growth. In under developed countries especially, the economic conditions lead to inflationary pressures due to its structural rigidities and imbalances. The inflationary increase in prices adversely affects the propensity to save and makes the investments less productive by producing the low real returns. Inflationary pressures reduce the purchasing power of the rupee, reducing the quantity of goods and services bought by the common man. Eventually this leads to a recession due to fall in aggregate demand. The monetary authority therefore should keep a constant vigil on the movement of prices and regulate the supply of money. The best remedy to control inflation is to reduce aggregate spending, encourage savings. For this, the central bank may raise the bank rate which would reduce the pressure of demand for bank credit by making borrowing costlier than before and this would discourage borrowing for speculative purposes. On the other hand, an increase in rate of interest also stimulates savings. To reduce the credit creating capacity of the banks further, the central bank may supplement the sale of government bonds and securities, raising the reserve ratios. Thus the central banks by relying on both the quantitative and qualitative instruments of credit control can limit inflation and helps in the process of growth.

With reference to Indian economy, Inflation has averaged around 5% since the mid-1990s as compared with around 8% during the preceding three decades. Inflation in India over therecent years has been comparable to that in other EMEs. Inflation did rise in 2007-10 because of higher food and fuel prices as in many other economies. Even as inflation continued, growth witnessed acceleration. Real GDP growth averaged almost 9% during the four years 2004-08. Due to the impact of crisis growth moderated to 6.7% in 2008-09 in contrast to outright contraction of activity in most economies. During 2009-10 India faced deficient monsoon due to which food grain production declined by 17 million tonnes. Towards the end of March, 20101 inflation was at 11 per cent headline inflation due to high increase in the prices of primary articles (inflation was 14.7) Fuel and petroleum products (inflation ranged from 10.3 to 14 per cent). In February 2010 food inflation has gone up to 21 per cent. Inflation rate moderated to anaverage of 7.3 per cent during 2012-13 from 8.9 per cent in 2011-12. The persistent of food inflation lead to spread of inflation in other sectors.

HISTORICALBACKGROUND

Inflation is major concern for any economy. There are several ways to measure inflation. To study the price movements in India, the Wholesale Price Index (WPI) is taken into consideration for all commodities. All commodities include primary articles, food and non-food articles, fuel and petroleum products, and manufacturing products.

Data used for thestudy:-
The annual data used for the current study are for 41 years, from 1972-1973 to 2011-2012. This study consists of following dependent and independent variables:

The dependent variable being: growth rates of Gross Domestic Product at Factor cost (at constant prices) with the Base year 2004-05.

The independent variables:-
- Wholesale Price Index with base year 2004-05 is taken as the proxy for inflation rate. (Inflation rate = WPIt– WPIt-1 / WPIt-1)
- Gross Domestic Capital formation is taken as the proxy for investment.
- Fiscal deficit
- Growth rates of agriculture GDP
- Threshold rate of inflation is a dummy variable which takes the values 0 and 1.

DataSource:-
- Hand Book of Statistics of the Reserve Bank of India (RBI)2012-13.

Methodology:-
- The present study uses the following methodology:
- Unit Root Process
- Multiple Regression and
- Granger Causality Test

Introduction to theMethodology:-
In this chapter, an attempt is made to present the various econometric tools employed in this study in a simplest fashion. Each econometric tool developed and tested by great econometricians is significant in its own way. Its applicability varies from place to place. Its relevance and scope in this attempt have to be clearly presented before the empirical study is taken up. Following the tradition, the data and methodology used in the study are elaborated in this chapter.

Under the Classical methods of estimation, we assume that the means and variances of the variables are well-defined constants and independent of time i.e. stationary. This is done because it was observed that for a large number of macroeconomic time series, the means and variances are not well defined. The means and variances alter as time progresses making the series non-stationary, the use of ordinary least squares (OLS) on such series results in spurious regression. This interprets that regressing time series on another may give a very highR^2value although there may exist no significant relationship between the two. Sometimes, the use of Ordinary Least Squares (OLS) in estimating the relationship between various variables could lead to out of order results if these are based on certain improbable assumption, that means and variances of the variables arewell definedconstants andindependent of time. Therefore the application of unit root tests is needed.

RegressionAnalysis:-
For this study Regression is used for estimating and hypothesis testing. A simple linear regression model correlates a dependent variable with an independent variable and estimates the relationship of thetwo:-

$y_t = \quad + \beta x_t + u_t$

Where$y_t$and $x_t$are the tthobservations on the *dependent* and *independent* variables respectively; $\alpha$and $\beta$are the unknown parameters to be estimated and are known as *regression coefficients*;$u_t$is the *unobserved error*, assumed to be having zero mean and constant variance. By adopting the method of and minimizing the error sum of squares, the regression coefficients are estimated.

RegressionCoefficient:-

For the simple linear model considered here, the coefficient measures the marginal contribution of the independent variables to the dependent variable, holding all the other variables fixed. If present, the coefficient of the C is the constant or intercept in the regression- it is interpreted as; when all of the other independent variables are zero what would the base level. The other coefficients are interpreted as the slope of the independent variables and to the dependent variable, assuming all other variablesdo not change.

Regression coefficient will give the rate of change in the dependent variable per unit change in the corresponding independent variable keeping the other variables constant. For example, in the above regression equation gives the rate of change in perunit change in $x_i$keeping the variablesconstant.

Standard Error:-
The _Std.Errorcolumn reports the standard errors of the coefficient estimates. Standard error measures the accuracy with which a sample embodies a population. The standard errors measure the statistical reliability of the coefficient estimates- the larger the standard errors, the more statistical noise in the estimates. The smaller the standard error, the more representative the sample will be of the overall population.

t-Statistic:-
In order to test the influence of each variable of the independent variables on the dependent variable, we have to test the significance of the corresponding regression coefficients.

The t-statistic is a proportion of the exodus of an estimated parameter from its estimated value and its standard error. To infer the t-statistic, one should study the probability of the t-statistic given that the coefficient is equal to zero.t-statistic is said to be significant if and only if the calculated value is greater than the critical or table value given the level of significance, otherwise it is insignificance.

Probability value(P-value):-
The last column of the output shows the probability value. It is the probability, of rejecting the null hypothesis of observing a test statistic [as much as, or more than] the one really observed. A p-value of .05 or less rejects the null hypothesis at the 5% level of significance. In other words, the p-value helps you determine the significance of independent variable on the dependent variable.

R-squared:-
R-squared value is also known as the coefficient of determination or multiple correlation coefficients. R^2 tells how a fitted regression can justify the changes in the dependent variable as a result of overall change in the variables. This R^2 measures the proportion of the total variation in dependent variable which can be explained by the regression equation. Therefore, R^2can be used to find out the goodness of fit and also to compare the validity of regression results under alternative specifications of the independent variable in the model.

AdjustedR-squared:-
The Adjusted R^2 is attempting to account for statistical shrinkage. Models with tons of predictors tend to perform better insample then whentested out of sample. The adjustedR^2"penalizes" you for adding the extra predictor variables that don't improve the existing model. It can be helpful in model selection. As you add more independent variables, the Adjusted R^2 will be smaller than R^2. Therefore, the Adjusted R^2 is a desirable measure to the goodness of thefit.

Durbin–Watsonstatistic:-
Before explaining the D-W Statistic, it is important to know the meaning and significance of _autocorrelation‘. Autocorrelation denotes to the relationship of a time series with its own past and future values. Autocorrelation can also confuse the identification of significant covariance or correlation between time series. The Durbin–Watson statisticsa test statistic used to identify the incidence of autocorrelation in the residuals (prediction errors) from a regression analysis. The Durbin-Watson statistic always lies between 0 and 4. A value of _2 ‘means that there is no autocorrelation.

F-Statistic:-

In order to find the combined effect of all the independent variables on the dependent variable and to know the goodness of fit of the model we use the F-test. F-statistic is a value which is used in regression analysis to decide if the variances between the means of two populations are significantly poles apart. In other words, it does this by comparing the ratio of two variances. So, if the variances are equal, the ratios of the variances willbe1.

Testing forStationarity:-

In order to examine whether a series is stationary or not, consider an AR (1) model:

$$Y_t = \ + \ _{-1} + \ _t$$

where α and β are parameters and υ(t) is assumed to be a white noise process. {Y} is a stationary series if ⎜β⎜< 1; if ⎜β⎜>1, then the series is explosive. Therefore, the hypothesisthat the series is stationary can be evaluated by testing whether the ⎜β⎜ is strictly less than 1.

Both the DF and PP tests take the existence of unit root as null hypothesis, H_0: β = 1. This *null hypothesis* is tested against the one-sided alternative H_1: β< 1; since explosive series do not make much economic sense.

The test is carried out by subtracting Y_{t-1} from both sides of the equation:-

$$\Delta Y_t = \ + \ _{-1} + \upsilon_t$$

Where δ = β-1 and the *null* and *alternative hypothesis* can be modified as:
H_0: δ = 0, i.e. β = 1 and H_1: δ< 0, i.e. β< 1.

As the t statistic under the null hypothesis of a unit root test does not have the conventional t distribution, Dickey and Fuller (1979) stimulated the critical values for selected sample sizes. MacKinnon (1991) implemented a much larger set of simulations than the values tabulated by Dickey and Fuller earlier.

The simple unit root test described above is only for the series which is an AR (1) process. If the series is correlated at higher order lags, the assumption of *white noise* disturbances is violated. The ADF and PP tests use different methods to control the for higher order serial correlation in the series. The ADF test makes an assumption that series{Y} follows an AR (p) process and adjusting the methodology of testing.

The ADF approach, adopted for this study, controls for higher-order correlation by adding lagged difference terms of the independent variable Y to the right hand side of the regression:

$$\Delta Y_t = \ + \delta Y_{t-1} + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \dots \dots + \theta_{p-1} \Delta Y_{t-p} {}_{+1} + \upsilon_t$$

This augmented specification is then used to test:-

H0: δ = 0, H_1: δ < 0.

Said and Dickey (1984) demonstrated that the ADF test remains valid even when the series has a moving average component, provided that enough lagged difference terms are augmented into regression.

Multiple RegressionModel:-

In the case of a multiple regression model, where the regressand is dependent on more than one regressor, the model is:

$$Y_t = \ _0 + a_1 X_{1t} + a_2 X_{2t} + \cdots + a_k X_{tk} + U_t$$

Where cov (X_i, U_t) = 0 and the Error Sum of Squares (ESS) are measured by:

$$\sum U^2 = \sum Y_t - a_0 - a_1 X_{1t} - a_2 X_{2t} - \cdots - a_k X_{tk} 2$$

By deriving the normalized equations:-

$$\sum Y_t = \ _0 + \alpha_1 \sum X_{1t} + \alpha_2 \sum X_{2t} + \dots \dots + \alpha_k \sum X_{kt}$$

$$\sum Y_{t t} X_{1t} = \alpha_0 \sum X_1 + \alpha_1 \sum X_{1t} 2 + \dots \dots + \alpha_k \sum X_{kt} X_{1t}$$

Till:-
$\sum Y_t X_{kt} = 0\sum X_{kt} + \alpha_1 \sum X_{1t} X_{kt} + \ldots\ldots + \alpha_k \sum X_{kt} 2 \quad --- \quad k+1$

Where αi is the estimated value ofai (i=0, 1…..k).
Thus, there are _k+1'unknown parameters and k+1 equation, utilizing which, the αis (i=0, 1…..k) can be estimated.

The t statistic, which is calculated as the proportion of the estimated coefficient to its standard error, is used to test the hypothesis that the coefficient (i.e. αis) is equal to zero.
Goodness of Fit of a Regression Equation

The goodness of fit is obtained by reducing the ESS to the least and to increase the correlation between the actual and estimated to the maximum extent.

The total sum of squares is given by:-
$TS = RSS + ESS$
$TSS = \sum Y_t - Y^{*2} + \sum U^2_t$

Where Y* is the mean of the dependent variable.
$RS = - SS -- fromequation 5.4.6$

Dividing both sides by TSS,

$$\frac{RSS}{TSS} = 1 - \frac{ESS}{TSS}$$

The correlation coefficient between actual and fitted is given by:

$$R^2 = \frac{RSS}{TSS}$$

$$R^2 = 1 - \frac{ESS}{TSS}$$

However, with the addition of any variable in the regression, the R^2 increases, whether the variable is related or not. Therefore, R^2 is adjusted for degrees of freedom,

$\bar{R}^2 = 1 - [(v\{U\}/v\{Y\})]$
$\bar{R}^2$ is adjustedR^2.

$$\bar{R} = 1 - \frac{\sigma \; n-1}{TSS}$$

(σ* being the standard error of estimation).
Greater adjusted R^2ensures higher the goodness of fitof the estimation.

GrangerCausality:-
Correlation does not imply meaningful causation. Correlations could be sometimes meaningless and spurious. Granger causality test performs pair wise granger causality tests between pairs of the listed series of group of series.

The null hypothesis for testing the causality is that the variables x does not granger cause variable y. If the result shows a small probability then this would lead to rejection of the null hypothesis that there is x doesn't granger cause granger cause y. which means that we accept the alternative hypothesis, the variable x is caused variable y. for any given two variables granger causality test determines the direction of the causality, whether x causes y or y cause x. It is important to note that the statement x granger cause y does not imply that y is the effect or the result of x. While doing the granger causality test, we need to decide on the ideal number lags to be used. Engle- granger causality model is used to test the causality between the two variables. The following is the model adopted in the study to empirically examine the hypothesis. X is said to be granger causes Y if Y can be predicted with granger accuracy by using past values of X.

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_1 X_{t-1} + u_t$$

If $\beta_1=0$, X does not granger cause Y. If, on the other hand, any of the β coefficients is non- zero, then X does not granger cause Y. The null hypothesis that $\beta_1 = 0$can be tested by using the standard F-test of joint significance. Note that if has been taken one period lag in the above equation. In practice, the choice of lag is arbitrary. Varying the lag length may lead to different result.

Insampleforecasting:-

The two important forecast statistics tools are Root Mean Square Error (RMSE) ad Their Inequality Coefficient (TIC).

Root Mean SquaredError:-

The Root Mean Square Error (**RMSE**) (also called the root mean square deviation, RMSD) is a frequently used measure of the difference between values predicted by a model and the values actually observed from the environment that is being modeled. These individual differences are also called residuals, and the RMSE serves to aggregate them into a single measure of predictive power. In this the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. RMSE can range from 0 to ∞. They are negatively-oriented scores: Lower values are better.

The RMSE of a model prediction with respect to the estimated variable X_{model} is defined as the square root of the mean squared error:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}}$$

Where $X_{obs}$is observed values and X_{model} is modeled values at time/place *i*.

The calculated RMSE values will have units, and RMSE for phosphorus concentrations can for this reason not be directly compared to RMSE values for chlorophyll *a* concentrations etc. However, the RMSE values can be used to distinguish model performance in a calibration period with that of a validation period as well as to compare the individual model performance to that of other predictive models.

TheilinequalityyCoefficient:-

Thiel's inequality coefficient, also known as Thiel's U, provides a measure of how well a time series of estimated values compares to a corresponding time series of observed values. Thiel's inequality coefficient is useful for comparing different forecast methods. The closer the value of U is to zero, the better the forecast method. If it is equal to zero then it perfect fit. If the value is one then it means that the forecast is no better than a naive guess.

The formula for the Theil inequality Coefficient is:-

$$Theil'sI = \frac{\sqrt{\frac{\sum^2_t}{T}}}{\sqrt{\frac{\sum y_t^2}{T}} + \sqrt{\frac{\sum \hat{y}_t}{T}}}$$

Empirical Results:-

In the following section, we present the results of the various empirical analysis carried out in the study. The analysis primarily aims at identifying the threshold rate of inflation in India and the relation between the economic growth and the inflation covering the period from 1971 to 2011. The threshold rate of inflation is defined with the help of dummy variable which takes the values 0 (when the inflation rate is less than or equal to the experimental threshold rate of inflation) and 1 (when the inflation rate exceeds the experimental threshold rate of inflation).

In this study we have estimated three models using dependent variable as growth rates of real GDP and inflation rate as the independent variable in the first model. Subsequently the second and third models are estimated using the growth rates of GDP as dependent variable and the growth rates of agriculture sector; capital formation (proxy variable for investments), fiscal deficit and threshold rate of inflation (dummy variable) at 5% in second model and 6% in the third model respectively. We use the econometric techniques of Unit Root Tests, OLS estimation and Granger Causality Test to carry out the proposed analysis.

Notations:-

- AGRGDP – growth rates of AgricultureGDP
- GDPGR - growth rates of Gross DomesticProduct
- FD - FiscalDeficit
- INVEST - Gross Domestic CapitalFormation
- THRESHOLD -Threshold rate ofInflation
- INF - WPIInflation

Unit RootTests:-

In order to avoid spurious results while dealing with time-series data, we need to check its stationarity using unit root test. On execution of the test for staionarity using the Augmented Dickey Fuller Test, Phillips Perron tests we need to check whether the variables.

Table:- Test for Stationarity Using Augmented Dickey Fuller Test.

VARIABLE	**t- statistic at levels**	**t-statistic at 1st difference**	**INFERENCE**
GDPGR	-7.916455	---	I(0)
INVEST	0.017128	-7.230377	I(1)
AGRGDP	-10.73460	---	I(0)
FD	-1.027815	-5.349588	I(1)
INF	-4.820686	---	I(0)

Mackinnon critical values:

1% level	-4.211868
5% level	-3.529758
10% level	-3.196411

Table :-Test for Stationarity Using Phillips-Perron Test.

VARIABLE	**t- statistic at levels**	**t-statistic at 1st difference**	**INFERENCE**
GDPGR	-10.06633	---	I(0)
INVEST	0.246290	-7.230377	I(1)
AGRGDP	-19.05219	----	I(0)
FD	-0.926479	-5.355995	I(1)
INF	-4.657242	---	I(0)

If the variable is not stationary at level I(0), then one needs to check the first difference and second difference. The stationarity of the variable can be adjusted by the estimated value which should be less than the critical value at various levels of significance. From the above tables 6.1 and 6.2 we can infer that GDPGR, AGRGDP, INF are stationary at levels. FD and INVEST are stationary at first difference in both ADF and PP tests.

OLSRegression:-

After ensuring the stationarity of the variables, the regression models have been constructed to explain the relationship among the variables. In this section we present estimated regression models.

Equation 1:-

Let us now estimate the simple OLS regression using growth rates of GDP and Inflation rate.

GDPGR = 7.22 - 0.22*INF

(8.70) (-2.54)

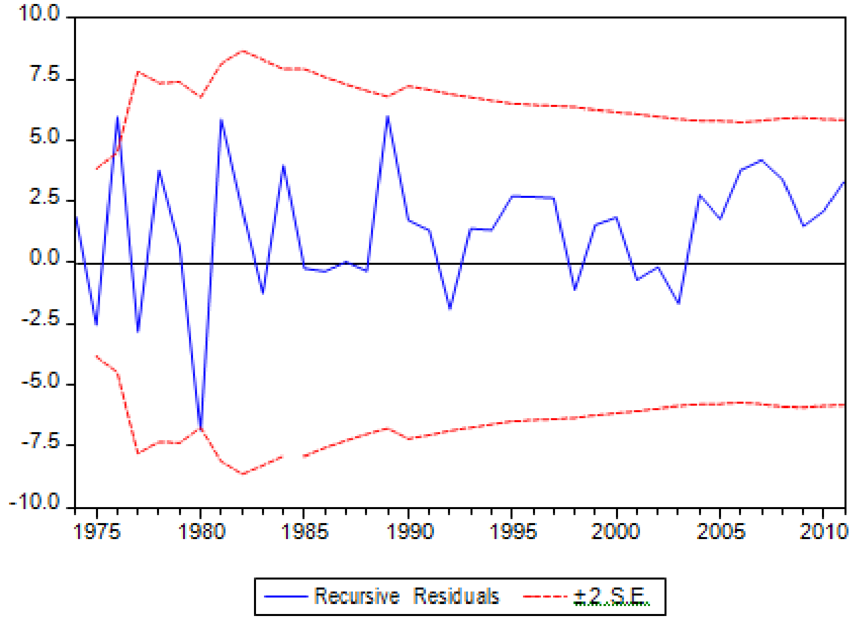
R^2=0.14	**$\bar{R}^2$=0.12**	
Durbin-Watson Stat=1.81	**F-Statistic=6.47**	**Prob.(F-stat)=0.015**
Note: values in parenthesis are t-statistic		

The above simple one variable regression represents the relationship between the economic growth and inflation. From the above regression equation it is evident that there is a negative relationship between inflation and economic growth. The co-efficient of inflation tells us by what magnitude the growth falls when there is 1 unit increase in inflation. The co-efficient of INF implies that 1 unit increase in the inflation rate reduces the GDP growth by .22 units. As we are considering only one variable in the model it has been found that only 14% of variation inthe dependent variable is explained by explanatory variable. Durbin-Watson Statistic of 1.81 shows that there is no serial correlation.

Figure:-Insample forecast for Equation 1:

RMSE:2.85Theil Inequality Coefficients:0.23

Figure:-Stability test for Equation 1:



The two important forecast statistics error are Root Mean Square Error (RMSE) and Their Inequality Coefficient (TIC). RMSE should be smaller indicating better forecasting ability of the model. The above results show a RMSE of 2.85(close to 3) indicates that the model is not useful for the forecasting. TIC is used here to study the predictive performance of the model and it should lie between 0 to 1. The results obtained in figure 6.1 shows a TIC of 0.23 implying that the forecasted series of model is close to the actual series and there is no systematic tendency to over or under estimate the actual data. In order to ensure that the parameters of the model are stable across various subsamples of the data, stability tests are used. As we have used OLS estimation recursive residuals are used to know the stability in parameters of the equation. Figure 6.3 shows that the recursive residuals for Model 1 about the zero line. Plus and minus two standard errors indicate the standard error band. If the residuals fall outside the standard error band, it suggests instability in the parameters in the model. In the figure above the recursive residuals lie in the standard error band indicating stability in the parameter of the model across various subsamples of thedata.

Equation 2:-

In this model the growth equation is explained by investment, growth rates of agriculture sector, threshold rate of inflation and fiscal deficit. In this model we take 5 per cent of inflation as the experimental threshold rate of inflation and estimate the growth model.

Threshold rate of inflation can be described as that inflexion point beyond which the economic growth is not optimal. Empirical studies have shown that at higher inflation rates than threshold level, the inflation rate has adverse influence on the economic growth. The threshold rate of inflation is defined with the help of dummy variable which takes the values 0 (when the inflation rate is less than or equal to the experimental threshold rate of inflation) and 1 (when the inflation rate exceeds the experimental threshold rate ofinflation).

THRESHOLD = Dummy Variable Dummy = 0 if $\prod < \prod^*$
= 1 if $\prod > \prod^*$

$\prod$ = actual inflation rate

$\prod^*$ = experimental threshold rate of inflation.

GDPGR = 3.70 + 0.0014*D (INVEST) + 0.39*AGRGDP+ 0.002*D(FD) - 0.46*THRESHOLD5 (9.34) (5.75)
(10.42) (3.48) (-1.05)

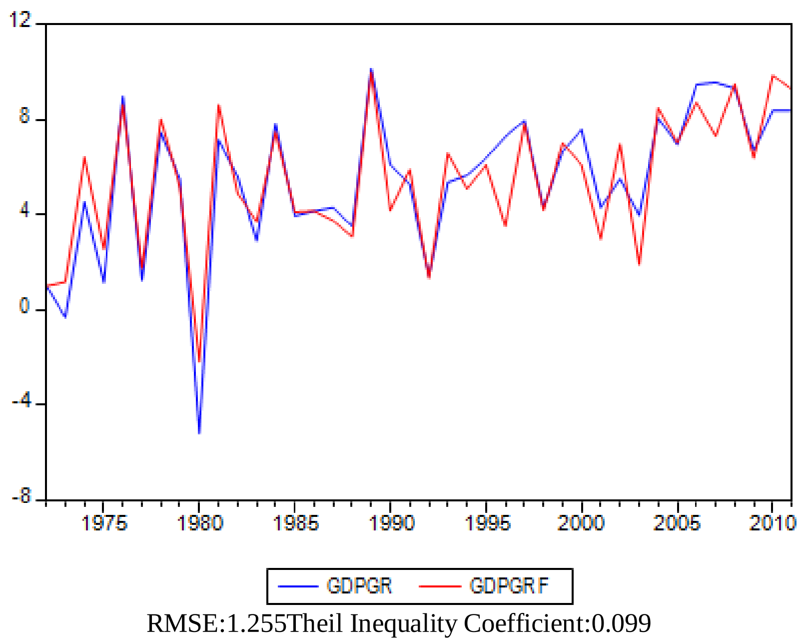
R^2=0.82 **$\bar{R}^2$= 0.80**
Durbin-Watson stat=1.82 **F-statistic=41.305** **Prob(F-statistic)=0.00000**

Note: values in parenthesis are t-statistic
In the above model GDP growth is positively influenced by investment, growth rates of agriculture and fiscal deficit. The GDP growth is inversely related to variable threshold rate of inflation. The t-statistics of all the variables, except the threshold variable, are statistically significant. As the investment activity increases the economic growth also increases. So there is a positive relationship between investment and economic growth. Similarly, there is a positive relationship between growth of agriculture and economic growth. Any increase in government's fiscal deficit leads better infrastructure and employment which in turn results in higher economic growth.

The Threshold variable is statistically insignificant with low t-statistic value. For the period considered the 5 per cent experimental threshold rate of inflation is not significant in Indian case. Though 5 per cent inflation has the negative impact on the economic growth, but it is not significant. So, we can conclude that for India 5 per cent inflation level is not considered as the threshold rate of inflation. Therefore, in the next regression equation we take inflation of 6 per cent as the experimental threshold rate of inflation. For every one unit change in the Investment, Fiscal deficits and Agriculture GDP there is less than unit change inthe GDP growth rate.

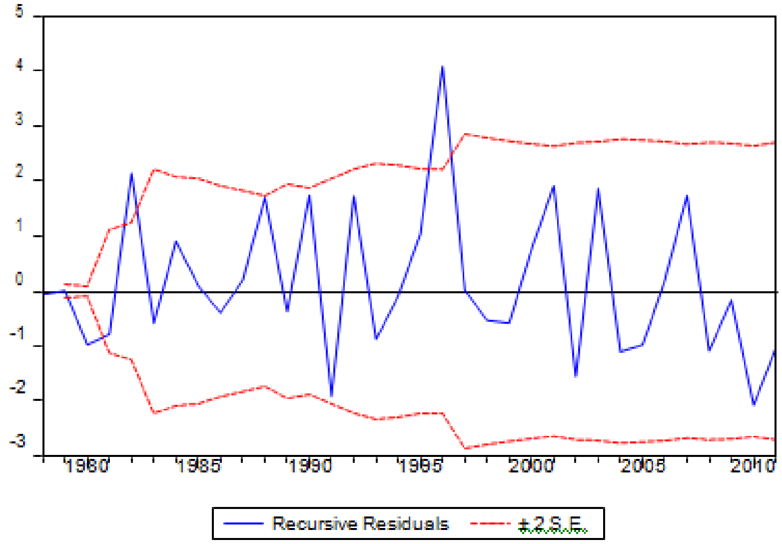
The R-squared and Adjusted R-squared values (0.829337 and 0.809258 respectively) indicate that the model explains more than 80 per cent changes in dependent variable. The Durbin-Watson stat (1.823197) shows that there is no serial or auto-correlation among the error terms. The high F-statistic (41.30562) tells us that the combination all the independent variable is significant and it is a good fit.

Figure :-Insample forecast for Equation 2:



RMSE:1.255Theil Inequality Coefficient:0.099

Figure : Stability test for Equation 2:



The figure 6.4 shows a RMSE of 1.255 indicating a good forecasting ability of the model. TIC of 0.09 which is close to 0 implying that the forecasted series of the model is closed to the actual series and there is no systematic tendency to over or under estimate the actual data. Figure 6.5 shows that recursive residuals of model lie in the standard error band except in the year 1995 due to high recorded inflation and negative growth in agricultural output. However, in all other periods the stability is maintained in the parameters of the equation.

Equation 3:-

In this model we estimate the growth equation by taking 6 per cent of inflation as the experimental threshold rate of inflation. In this regression equation we estimate the model 2 as it is but replacing the variable THRESHOLD5 with THRESHOLD6.

GDPGR = 4.17 + 0.0012*D (INVEST) + 0.38*AGRGDP + 0.0017*D(FD)- 1.99*THRESHOLD6 (13.8)(5.69)

(12.19) (3.44) (-4.06)

R=0.88 **$\bar{R}^2$=0.86**

Durbin Watson=2.04 **F-statistic=63.15** **Prob (F-statistic) =0.0000**

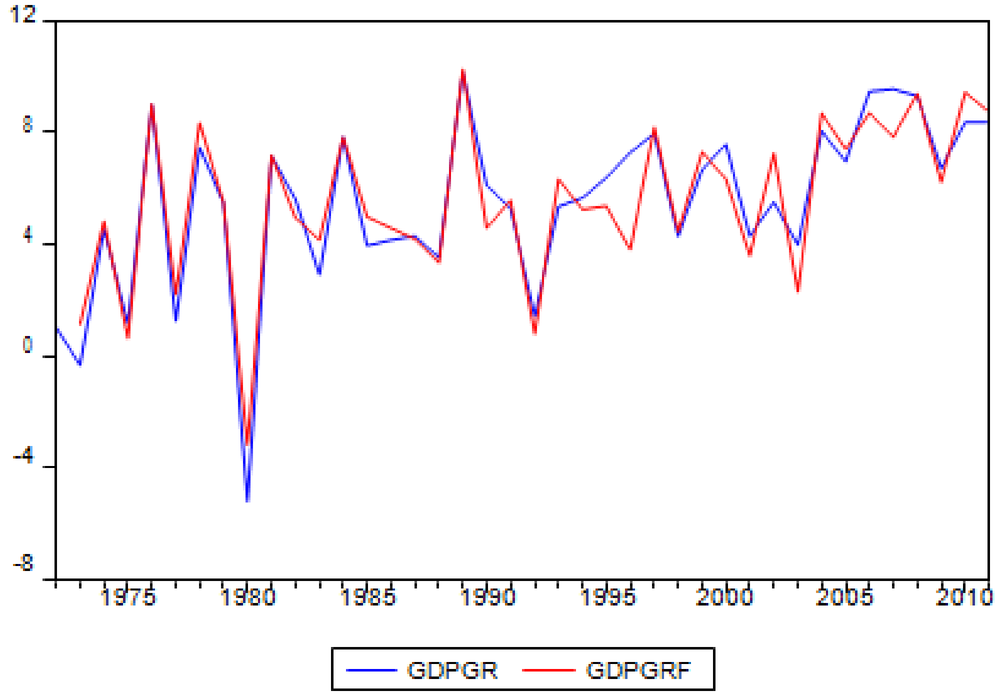
Note: values in parenthesis are t-statistic

In this regression equation all the variables are statistically and theoretically significant. The economic growth positively related with investment, growth of agriculture and fiscal deficit and inversely related with threshold rate of inflation.

The R-squared and Adjusted R-squared values (0.881369 and 0.867413 respectively) indicate that the model explains more than 86 per cent changes in dependent variable. The Durbin-Watson stat (2.041401) shows that there is no serial or auto-correlation among the error terms. The high F-statistic (63.15094) tells us that all the explanatory variables together are significant in the model which is also a sign of good fit.

1 unit increase in inflation rate of 6 per cent will lead to 1.99 units fall in the economic growth. It is evident from this equation that inflation more than 6 per cent will have significant and robust adverse effect on the economic growth. Therefore, we conclude that the appropriate threshold rate of inflation for Indian Economy is 6 percent.

Figure:-Insample forecast for Equation 3



RMSE:1.04Theil Inequality Coefficients0.08

Figure:-Stability test for Equation 3.

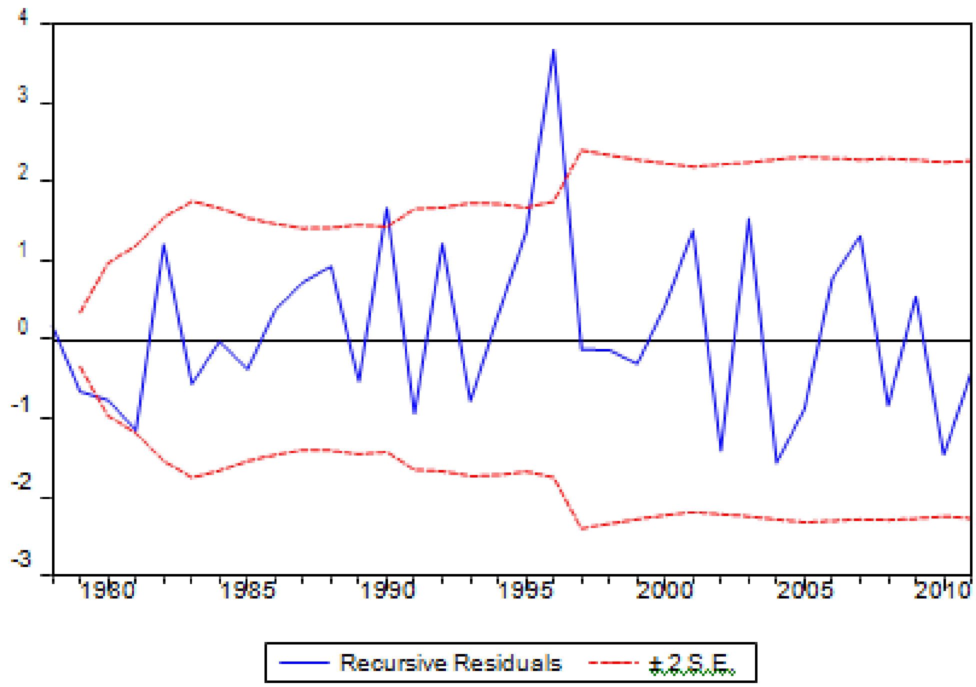


Figure 6.5 shows a RMSE of 1.04 indicating a good forecasting stability of the model. TIC of 0.08, which is very close to zero, implies that the forecasted series of the model is closed to actual series and there is no systematic tendency to over or under estimate the actual data.

Figure 6.6 shows that recursive residuals of model lie in the standard error bandexceptinthe year 1995 due to high recorded inflation and negative growth in agricultural output. However, in all other periods the stability is maintained in the parameters of the equation.

Granger CausalityTest:-

If two or more variables are cointegrated then causality in the Granger sense must exist in at least one direction (Granger, 1986; 1988). However, cointegration indicates presence or absence of Granger causality; it does not indicate the direction of causality. But, in regression involving time series data, the situation may be somewhat different because, as oneputsit,–timedoesnotrunbackward i.e., ifevent Ahappensbeforeevent B,thenit is possible that A is causing B. However, it is not possible that B is causing A. In other words, events in the past can cause events to happen today.Thisis roughly the idea behind the Granger Causality Test. We test whether the independent variables granger cause the GDP growth and vice-versa. We use 2 lags, assuming that it takes one year for economy to fully absorb the changes in the independent variables. The independent variables that tested here are inflation, investment, fiscal deficit and growth of agricultureGDP.

Table:- Pair wise Granger Causality Test between growth rates of GDP and Independent Variables.

Null Hypothesis:	F-Statistic	Probability
INF does not Granger Cause GDPGR	2.24352	0.12202
GDPGR does not Granger Cause INF	1.61367	0.21448
INVEST does not Granger Cause GDPGR	6.53901	0.00405
GDPGR does not Granger Cause INVEST	0.08349	0.92009
AGRGDP does not Granger Cause GDPGR	5.39877	0.00937
GDPGR does not Granger Cause AGRGDP	0.33565	0.71728
FD does not Granger Cause GDPGR	3.48463	0.04236
GDPGR does not Granger Cause FD	2.06910	0.14238

The above results show that investment, growth rates of agriculture GDP and fiscal deficit granger causes growth rates of GDP. The Null hypothesis of no causality is rejected at 5% level of significance, which explains that there is causality relationship from all independent variables to growth rates of GDP except the inflation. Only inflation does not granger growth rates of GDP.

Summary andConclusions:-

The present study aims at studying the relationship between economic growth and inflation in Indian Economy. The study also aims to find out the appropriate threshold rate of inflation in Indian Economy. This study uses secondary time series data. The annual data is obtained for the period 1971-2012.

We have built three models. The first model shows the simple regression model using dependent variable, growth rates of real GDP, which is explained by inflation rate. The results show that the explanatory variable has a negative relationship with dependent variable and it is significant in explaining the dependent variable.

The second model shows the dependent variable growth rates of real GDP which is explained by the investment, growth rates of agriculture GDP, fiscal deficit and the threshold rate of inflation (dummy variable). In this model 5 per cent of inflation is taken as the experimental threshold rate of inflation. The econometric result goes in consonance with the theory by establishing a positive relationship between growth rates of real GDP and investment, growth rates of agriculture GDP, fiscal deficit. There is inverse relationship between the growth rates of GDP and threshold rate of inflation. However, the t-statistic of threshold rate of inflation suggests that it is statistically insignificant. Hence for the time period considered, threshold level of inflation at 5% does not have any role in determining the GDP growth.

Similar to the second model, using the threshold level at 6% and keeping the other independent variables intact we have estimated the third model. In this model all the explanatory variables are statistically and theoretically significant. In this model 6 per cent of inflation is accepted as the appropriate threshold rate of inflation for Indian economy. It also denotes that when the inflation exceeds the 6 per cent of threshold rate of inflation it retards the economicgrowth.

Insample forecast done for the three models suggest that the forecasted series of model 2 and model 3 are close to the actual series implying that there is no tendency to under or overestimate the actual data. The stability test used for each model reveals that the parameters of the models are stable across various subsamples ofdata.

Granger causality results show that the investment, agriculture growth rates, fiscal deficits are the causes for GDP growth. Inflation is not a dominant factor for GDP growth. These findings contribute to the existing literature, empirical studies available on threshold inflation and economic growth.

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