AN EMPIRICAL STUDY OF PHILLIPS CURVE IN INDIA

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Abstract
Inflation and Unemployment are the two important variables in macro economics.The phenomenon of high inflation and unemployment is generally bad and London School of Economics, who brought out a study of relationship between unemployment rate and change in money wage rates in the British economy during the period 1861-1957.The study brings out the fact that the past studies have found mixed evidence about the shape of the Phillips curve from being horizontal to vertical. The researcher has also observed that there are very few studies about the developing countries including India. The present finding does not support the hypothesis of vertical Phillips curve. There is a trade-off between prices and unemployment. Rather it suggests that there is a short run Phillips curve in India. The study is based on secondary sources of data. Regarding data source have been taken from Handbook of Statistics on Indian Economy, RBI and construction of variables, are used the Indian annual data for the period 1951-52 to 2007-08.
Key Words: Gross Nation Product(GNP) Deflator, Okun's law, Adaptive Expectation, Growth rates and Output gap ratio.

Introduction

Inflation and Unemployment are the two important variables in macro economics. Management of these two variables are received the maximum attention of those who are entrusted with the responsibility of managing their respective economies of the world. Reasons for the priority and urgency to control inflation and unemployment can be appreciated only after knowing their causes and consequences for the society.

There are several effects of inflation. It has adverse impact on income distribution. A price rise tends to benefit some individuals and harm others. While for some income earners, income rises more rapidly than prices during inflation, for many people just the opposite is true. Those who have fixed incomes are seriously affected as the real income decline during periods of inflation.

Inflation also has effect on lending and savings. Inflation benefits the borrowers at the expense of the lenders and savers. The saving rate and hence investment rate is affected adversely. Inflation, in a country, has also adverse effects on foreign trade. The competitiveness of a country may be seriously affected.

Regarding unemployment, economists general classify unemployment into three types according to the causal factors, namely, frictional unemployment, cyclical unemployment and structural unemployment. Sometimes seasonal and disguised unemployments are also mentioned. The structural unemployment refers to the persons who are between the jobs. Cyclical unemployment results from business recessions and depressions when total spending in the economy is below the full employment productive capacity of the economy. In such a situation, the economy has same natural resources, manpower and productive equipment as before the cyclical unemployment occurred but the problem is that economy does not produce because the goods and services being produced are not being purchased. The people were not buying because they either had lost their jobs or feared the loss of their jobs. Structural unemployment arises due to a mismatch between job seekers and job openings. It refers to a situation when

both the jobs and job seekers exist but something prevents the filling up the vacancies.

Unemployment has both economic and social implications for a country like India. Occurrence of unemployment results in the loss of output, loss in revenue of the government and in consequence disastrous effect on developmental works. The social cost of unemployment can not be measured in money terms, but it involves an intolerable amount of human suffering. Unemployment means loss of self-respect, poverty and frustration. It can even lead to social unrest in the country. There are other types of unemployment also in developing countries like India. These are underemployment and disguised unemployment. Disguised unemployment refers to zero or very low productivity level and is most prevalent in Indian agriculture sector. The presence of this type of unemployment makes functioning of labour market inefficient.

Having discussed the causes and consequences of inflation and unemployment, obviously, it would be extremely desirable to reduce or eliminate altogether, if possible, the menace of inflation and unemployment.This requires, however, the knowledge of relationship between unemployment and inflation. This relationship is exhibited by "Phillips curve" named after its originator, Australian economist AW Phillips. According to Phillips curve, there is a trade-off between inflation and unemployment. Thus, policy makers face a serious dilemma. Efforts to reduce unemployment usually result in increased inflation, while efforts to decrease inflation usually bring about an increase in the unemployment rate. Ever since, the contribution made by AW Phillips, a number of studies have been done to know the nature of relationship empirically between inflation and unemployment in the context of different countries, so that suitable policies can be formulated. The findings are not conclusive and different studies have come out with different evidences. Another important part of the debate the Phillips curve involves a disagreement among the investigators about whether unemployment causes inflation or inflation causes unemployment.

Statement of Problem and Objectives of the study

The phenomenon of high inflation and unemployment is generally bad and should be avoided if possible. There is considerable disagreement over which of the two is more harmful. Since, a certain amount of inflation and unemployment is unavoidable and since efforts to reduce one, usually result in an increase in the other. Growing volume of literature on the theoretical foundation of the celebrated Phillips curve has clearly established that the trade-off between inflation and unemployment is essentially a short run phenomenon. Expectation augmented Phillips curve ensures that unemployment would remain at its natural rate irrespective of the rate of inflation in the long run. This is also shown that the expectation formation about inflation makes the short run Phillips curve an unstable curve. The result of the previous study on the India examined the Phillips curve has same shape as the aggregate supply curve. As the policy measures to contain inflations and unemployment differ with difference in the shape of Phillips curve, the determination of the shape of Phillips curve becomes very important. The present work is a modest attempt towards that end. Another issue that deserves investigation is regarding causation between inflation rate and unemployment rate. Objectives are given below:

1. To estimate the Expectation Augmenting Phillips curve and interpret the results.
2. To avoid spurious regression, the series of observations on the relevant variables

are tested for their unit roots or stationarity.
3. To conduct Granger Causality Test for different pairs of variables.

Limitation and significance of the study

The major limitation of this study is non availability of data on unemployment. No source provides comprehensive, regular and reliable data. Census of India collects data on labour force with a gap of 10 years. Similarly National Sample Survey Organisation(NSSO) conducts survey after five years. The number of unemployed registered with employment exchanges is also highly unreliable. Moreover, definition of unemployment adopted by these sources is also not uniform. The significance of the study lies in the fact that knowledge of the nature or relationship between inflation and unemployment can enable the policy makers to formulate policies to minimize the harmful consequences of inflation and unemployment for the society.

Analytical Framework: Expectations Augmented Phillips Curve

Economists had looked into the relationship between unemployment and inflation before 1958. Infact, a variant of this relationship was investigated as early as 1926 by Irvin Fisher[1]. However, it was AW Phillips[2] a British economist at London School of Economics, who brought out a study of relationship between unemployment rate and change in money wage rates in the British economy during the period 1861-1957. The equation that was chosen to fit the actual data is,

$$Infl(w) + a = b\,U^{\gamma}$$

where, Infl(w) is the rate of change of wage rate, U is percentage unemployment a,b and γ are parameter constants b and γ were estimated by applying the least squares method constant, a, was obtained through "trial and error" method. Phillips found an inverse relationship between the rate of change in money wage rate and the rate of unemployment. This finding of inverse relationship between wage growth rate and unemployment led to the notion that there might be a trade-off between unemployment and inflation. The perception is that if the government tries to reduce inflation by constrictionary monetary and fiscal policy, then unemployment will surely rise. Thus one would expect a negative correlation between unemployment and inflation. The unusual method employed to estimate the equation given above invited criticism from many quarters.

Richard Lipsey[3] worked on the same data and makes some modification in the original equation of AW Phillips and proposed to estimate an alternative equation given below. He estimated this equation by applying standard statistical technique.

$$Infl(w) = a + bU^{-1} + cU^{-2}$$

Lipsey repeats Phillips's work but uses standard statistical techniques to eliminate the econometric problems associated with Phillips's method. His equation can be made arbitrarily close to the oneestimated by Phillips by choosing appropriate values for the parameters a,b and c. Thus if Phillips's equation were correct, it would be corroborated by the fit for Lipsey's equation. However, the parameter magnitudes obtained by Phillips do not corroborate the Phillips estimates, though he does obtain a negative non-linear relationship confirming Phillips basic findings. Thus, a simple Phillips curve, depicting a inverse relationship between growth rate of nominal wages and unemployment rate, can be written as:

[1]Fisher Irving(1926).
[2]A.W.Phillips(1958).
[3]R.G.Lipsey (1960).

$$Infl(w) = - \delta (U) \quad \ldots.(1)$$

where, Infl(w) is wage growth rate and , U, is actual unemployment rate. δ, is a positive constant representing the sensitivity of wage growth rate to the change in unemployment rate.

After this, a number of rationalizations for the existence of a negative relationship between wage inflation and unemployment have been given in the literature. Phillips has been criticized for his failure to provide theoretical basis of the negative relationship between wage inflation and unemployment rate.

Friedman(1968) in an alternative explanation argued that short-run Phillips curve, which are not vertical , arise due to the misperception of workers as to whether real wages have also increased following an increase in the nominal wages. Friedman claimed that Phillips had made three mistakes (i) he failed to distinguish between nominal wages and real wages (ii) he ignored temporary and, permanent trade-offs between wage inflation and unemployment rate and (iii) he did not assign a role to expected inflation. According to Firedman, there is only one long run, i.e. natural rate of unemployment which is compatible with any perceived rate of inflation. Hence, there is a series of short run Phillips curves each conditional on expected rate of price inflation.

Following Friedman's contribution in terms of distinction between nominal and real wage rate, inflation expectations, and natural rate of unemployment, the modified Phillips curve- Inflation expectations augmented Phillips curve in equation (1) can be written as[4]:

$$Infl(GNPD) = Infl(GNPD)^e - \delta (U - U^*) \quad \ldots.(2)$$

where, Infl(GNPD) is actual price inflation rate[5], $Infl(GNPD)^e$ is expected inflation rate, U is actual unemployment rate, U* is natural(long run) unemployment rate, δ is a positive constant which represents the response of price inflation rate to a change in the deviation of actual unemployment rate from natural rate of unemployment.

More recent explanations of Phillips curve have stressed the importance of imperfect competition. According to this explanation wages are set through bargains between trade unions and employers. The natural rate of unemployment in Friedman's model is replaced with the non-accelerating inflation rate of unemployment[6] - NAIRU. If unemployment is less than NAIRU unions bargain for a wage greater than at equilibrium. Money wages increase more than NAIRU and so do product prices as employers respond to their potential loss of profit per unit of output. Lower unemployment is associated with higher wage and hence price inflation; there is a Phillips curve at least in the short run.

From operational point of view, however, the expectations augmented Phillips curve (2) requires further elaboration on NAIRU or natural rate of unemployment (U*) and expected inflation $Infl(GNPD)^e$.

Natural rate of unemployment or the long run unemployment rate is measured by the trend rate of unemployment. For modeling the expectations of inflation rate, there are two approaches; adaptive expectation model and rational expectations[7] model. In the

[4] Dornbusch, Fischer and Startz (2002). P.104

[5] Assuming a constant real wage rate, actual price inflation rate Infl(GNPD) , will be equal to nominal wage inflation rate (Infl(w)).

[6] The NAIRU can be estimated by identifying a rate of unemployment where the inflation rate neither accelerates nor deaccelerates.

[7] The expectation of a variable is said to be rational for a given information set if it is the same as the conditional expectation of that variable.

present work, we have employed adaptive expectations scheme according to which the current expected price inflation is equal to the one period lagged actual price inflation[8] i.e.,

$$Infl(GNPD)^e = Infl(GNPD)_{-1} \quad \ldots.(3)$$

Thus, in light of (3), the expectation augmented Phillips curve (2) becomes,

$$Infl(GNPD) = Infl(GNPD)_{-1} - \delta (U- U^*) \quad \ldots.(4)$$

It is obvious equation (4) that empirical implementation of the expectation augmented Phillips curve given by equation (4) would require data on unemployment in addition to prices. The empirical investigators has to proceed by recognizing the limitation of non-availability of data on unemployment in India. Like any other low developed countries, India has no comprehensive data on the extent of overall unemployment. Broadly, there three sources of data on unemployment in India. First is the population census which collects information on economic activity of the people. The census data provides an inventory of human resources of the country showing their number, characteristics, occupation and distribution among various branches of economy with 10 years gap. For growth of labour force the classification followed is: main workers and marginal workers; rural and urban workers ; mail workers and female workers. Second, National Sample Survey Organisation(NSSO) has been conducting quinquennial surveys on a regular basis since 1972-73 to generate national level data on unemployment and employment in India. The NSSO has, over time developed and standardized measures of employment and unemployment. But these surveys are done with a gap of 5 years in the initial stages. The NSSO collects data on employment and unemployment using three broad measures or approaches on urban and rural population 1. Usual Status; 2. Current Weekly Status; and 3. Current Daily Status. Third, sources is on the basis of registration in the employment exchanges which gives a gross under estimate of unemployment in India.

Thus, it can be said that no source provides regular, reliable and well defined long time series data on unemployment in India. And therefore, a meaningful source of data on unemployment to be employed for the estimation of expectations augmented Phillips curve can be treated as non-existent. Therefore, we need to reformulate equation (4) in a way that can be estimated from a reasonably reliable and available set of data.

To that end, expectation augmented Phillips curve in equation (4) can, for the save of convenience, can be written as:

$$Infl(GNPD) = Infl(GNPD)_{-1} - \delta (U- U^*) - h(U-U_{-1}) \quad \ldots.(5)$$

where, $Infl(GNPD)$ and $Infl(GNPD)_{-1}$ represent respectively actual and expected rates of inflation. U, U_{-1}represent respectively the current and lagged unemployment rates; and U^*, δ and h are positive parameters the natural rate of unemployment, the sensitivity of prices to the labour market disequilibrium, and the sensitivity of the rate of inflation to the rate of recovery in the economy.

Since simple Phillips curve lies at the root of the aggregate supply curve and the two differ only in terms of gap between unemployment rates and output respectively, it is possible to write,

$$U^*- U = \alpha ((y-y^*)/ y^*) \quad \ldots. (6)$$

where α is a positive constant such that $\alpha = 1-U^*$.

[8] According to adaptive expectation scheme $Infl(GNPD)^e - Infl(GNPD)^e_{-1} = \lambda[Infl(GNPD)_{-1} - Infl(GNPD)^e_{-1}]$, where λ is speed of adjustment , $0<\lambda\leq 1$ when $\lambda=1$, $Infl(GNPD)^e = Infl(GNPD)_{-1}$.

Similarly, a close link can be established between changes in the unemployment rate over time and the deviation of actual output growth from the trend rate of growth. Okun(1983) formally quantified such a relationship which is now knowns a 'Okun's Law'. It can be written symbolically as;

$$U-U_{-1} = -(1/q)\ (Gy-Gy^*) \quad \ldots.(7)$$

where, q is Okun's parameter reflecting the cost of cyclical unemployment; and Gy and Gy* are respectively the actual and trend rates of output growth.

Substituting equation (6) and (7) in equation (5) we get

$$Infl(GNPD) = Infl(GNPD)_{-1} - \delta((y-y^*)/ y^*) - h/q(Gy-Gy^*) \quad \ldots.(8)$$

This form of inflation augmented Phillips curve can be estimated empirically with the help of the data on price and output. The explicit mention and requirement of unemployment data is avoided.

Equation (8) represents our basic equation for the expectation augmenting Phillips curve. A deterministic version of the equation to be empirically estimated can be stated as :

$$Infl(GNPD)_t = \beta_0 + \beta_1\ Infl(GNPD)_{t-1} + \beta_2((y_t-y_t^*)/ y_t^*) + \beta_3(Gy-Gy^*) \quad \ldots.(9)$$

where, β_0, is intercept and represents the 'autonomous' rate of inflation which is independent of the expected rate of inflation, the output gap (unemployment rate), and the deviation of actual from potential output growth rate (rate of recovery) in the economy. β_1 is the coefficient of expected rate of inflation and is important for making a distinction between short run and long run Phillips curve. If $\beta_1=0$, it means there is complete money illusion in the wage bargaining process. It would be money wage rather than real wage that mattered. If $\beta_1=1$, it implies that there is no long run trade-off between inflation rate and unemployment rate and the Phillips curve is vertical in the long run. If $0<\beta_1<1$, then the long run Phillips curve is not vertical. β_2 represents sensitivity of wages(hence prices) to the labour market disequilibrium and determines the slope of the Phillips curve. β_3 , represents the sensitivity of the rate of inflation to the rate of recovery in the economy.

Techniques of Analysis and Interpretation of Results

To estimate the equation of the modern extended Phillips curve through regression technique, the times data on inflation rate, lagged inflation rate, output gap ratio and gap of output growth rates. But while regressing a time series variable on another time series variables one often gets very high R^2 and significant coefficient estimates even when there is no meaningful relationship between the variables. Sometimes we do not expect any relationship between variables, yet a regression of one on the other variables shows a significant relationship. This situation is indicative of a problem of spurious or non-sense regression. It is therefore very important to find out if the relation between economic variables in spurious or nonsensical. The regression analysis assumes that the underling time series are stationary and have no unit roots. A test of stationarity(for non-stationarity) that has become widely popular in the unit root test.

4.1 Unit Root Test

Augmented Dicky-Fuller Test

In this paper, we employ the Augmented Dicky-Fuller (ADF) test to test the stationarity of the four time series, namely,Infl, $Infl_{-1}$, (y – y*) / y* and (Gy – Gy*).

The table 4.1 shows that computed value of the ADF statistic (-3.36) is less than the critical value (-2.92) at 5 percent

level of significance. Therefore the null hypothesis that the time series Infl(GNPD) is non-stationary or has a unit root is rejected at 5 percent level of significance. It implies that the series Infl(GNPD) is stationary. Similarly, in case of the model with trend and intercept the null hypothesis that the series on Infl(GNPD) is not stationary or has a unit root is rejected at 10 percent level of significance as the computed value of ADF statistic (-3.01) is less than the critical value(-3.18). Therefore, Infl(GNPD) is stationary.

In case of $Infl_{-1}$(GNPD), the ADF statistic value (-5.69) is less than the critical value (-3.56) for intercept model and ADF statistic (-9.04) is less than the corresponding critical value (-4.14) for the intercept and trend model which means the null hypothesis that the time series $Infl_{-1}$(GNPD) is non-stationary or has a unit root is rejected at 1 percent level of significance on the basis of both the models.

Similarly, in case of a series of output gap ratio, $((y_t-y_t^*)/y_t^*)$, the table shows that the ADF statistic value (-29.74) is less than the corresponding critical value (-3.56) in case of intercept model, and value of ADF statistic (-56.55) is less than the corresponding critical value (-4.14) in case of time trend and intercept model. These values imply that the null hypothesis about time series on output gap ratio being non-stationary or having a unit root rejected at 11 percent level of significance.

As far as, the time series on the gap of output growth rates, $(G_y-G_y^*)$ is concerned the value of ADF test statistic (-3.37) is less than the corresponding critical value (-2.92) in case of intercept model which implies that the null hypothesis of no stationarity is rejected at 5 percent level of significance. Similarly, on the basis of intercept and trend model, the hypothesis of no stationarity or of having a unit root is rejected at 10 percent level of significance as the value of ADF statistic (-3.01) is less than the corresponding critical value (-3.18) at 10 percent level of significance. Thus, all the variables (in level) are stationary on the basis of ADF test at either one, five or ten percent level of significance. All the time series are stationary at first difference.

Table: 4.1

Augmented Dickey-Fuller Unit Root Test Results

Variables	Model	Level	First Difference
Infl(GNPD)	Intercept	-3.3561**	-6.1534*
		(-2.9178)	(-3.5625)
	Trend & Intercept	-3.0087***	-6.2317*
		(-3.1772)	(-4.1458)
$Infl(GNPD)_{-1}$	Intercept	-5.6877*	-5.4957*

		(-3.5598)	(-3.5625)
	Trend & Intercept	-9.0367*	-6.4307*
		(-4.1420)	(-4.1458)
Output Gap Ratio $((y_t-y_t^*)/ y_t^*)$	Intercept	-29.7438*	-27.7016*
		(-3.5598)	(-3.5625)
	Trend & Intercept	-56.5468*	-29.9754*
		(-4.1420)	(-4.1458)
Gap of output Growth Rates (Gy-Gy*)	Intercept	-3.3724**	-6.0806*
		(-2.9190)	(-3.5653)
	Trend & Intercept	-3.0132***	-6.1648*
		(-3.1782)	(-4.1498)

Note: (i) The figures are the values of ADF test statistic and the brackets contain thecritical values.
(ii)* significant at 1 percent level
(iii)** significant at 5 percent level
(iv)*** significant at 10 percent level

Phillips-Parron Test

The time series on Infl(GNPD) was found to be stationary as the PP value (-4.63) is less than the corresponding critical value (-3.55) at 1 percent level of significance as the null hypothesis of non stationarity was rejected in case of intercept model.

Similarly, in case of intercept and trend model the null hypothesis of presence of unit root test was rejected as the PP value (-4.75) is less than the corresponding critical value(-4.13) at 1 percent level of significance.

Regarding the time series of lagged inflation, the null hypothesis of non stationarity was rejected in the context of both the models, the intercept model with PP value (-7.40) being less than critical value (-3.55), and the intercept and trend model with PP value (-7.59) being less than the critical value (-4.13).

Regarding the time series of output gap ratio, the estimates of intercept model show that the null hypothesis of no unit root is rejected at 1 percent level of significance as the PP value(-7.41) is less than the critical value (-3.55). Similarly the estimates

of trend and intercept model as shown in the table reveal that the null hypothesis of no unit root is rejected at 1 percent level of significance as the PP value (-7.43) is less than the critical value (-4.13) at 1 percent level of significance. Therefore, on the basis of the Phillips-Parron test the time series of output gap ratio is stationary at levels.

Regarding the time series of gap of output growth rates, the PP value (-4.595) is less than the critical value (-3.55) in the context of intercept model. This implies that the null hypothesis of no stationarity is rejected at 1 percent level of significance. In case of trend and intercept model also, the PP value (-4.74) is less than the critical value (-4.13) at 1 percent level of significance. Therefore the hypothesis of presence of unit root is rejected at 1 percent level of significance. Thus, all the four time series are stationary on the basis of Phillips-Parron test on the basis of the two specifications with intercept only model as well as with trend and intercept model at their levels. Obviously, when the series are stationary at levels, they must be stationary in their first difference is shown in the tables.

The graphs of the four time series in their level as well as first difference have been shown in figure (4.1) and (4.2) respectively. The stationarity of these series is also seen from these figures.

Table: 4.2

Phillips-Parron Unit Root Test Results

Variables	Model	Level	First Difference
Infl.(GNPD)	Intercept	-4.6325*	-11.2496*
		(-3.5501)	(-3.5523)
	Trend & Intercept	-4.7514*	-11.3510*
		(-4.1281)	(-4.1314)
$Infl(GNPD)_{-1}$	Intercept	-7.3975*	-17.0502*
		(-3.5501)	(-3.5523)
	Trend & Intercept	-7.5947*	-16.9423*
		(-4.1281)	(-4.1314)
Output Gap Ratio $((y_t-y_t^*)/ y_t^*)$	Intercept	-7.4062*	-16.5800*
		(-3.5501)	(-3.5523)

Gap of output Growth Rates (Gy-Gy*)	Trend & Intercept	-7.4313*	-16.4482*
		(-4.1281)	(-4.1314)
	Intercept	-4.5954*	-11.1390*
		(-3.5523)	(-3.5547)
	Trend & Intercept	-4.7397*	-11.2520*
		(-4.1314)	(-4.1348)

Note: (i) The figures are the Phillips-Parron statistic values and the brackets contain the critical values.
(ii) * indicates significance at 1 percent level.

4.2 Estimates of Phillips curve and their interpretation

Equation (9) represents our basic equation for the expectations augmented Phillips curve. The stochastic version of equation (9) to be estimated empirically would be:

$$Infl\ (GNPD) = \beta_0+\beta_1 Infl(GNPD)_{-1}+ \beta_2((y - y^*)/y^*)+\beta_3(G_y - G_{y^*})+u \quad ....(10)$$

where β_0 and β_i 's are parameters and u is the random error term with the usual OLS assumptions .

Regarding data source have been taken from Handbook of Statistics on Indian Economy, RBI and construction of variables, we have used the Indian annual data for the period 1951-52 to 2007-08 for estimating the equation (10). Regarding rate of inflation, the rate of change in GNP Deflator has been used as a measure of inflation. The GNP deflator was obtained by dividing the GNP figures at current prices by those at constant prices. Gross National Product (GNP) at constant prices of the year 1999-2000 has been used as a measure of output. All the growth rates in prices and output are annual rates based on continuous compounding. The output gap is measured as a difference between actual output and trend value of output obtained by fitting the linear time trend of the GNP at (1999-2000) prices.

Table: 4.3

OLS Estimates of equation of augmented Phillips curve

(1951-52 to 2007-08)

Dependent Variable:- Infl(GNPD)

Variables	Coefficient	STD Error	T-Statistics
Infl (GNPD) $_{-1}$	0.3365*	0.1185	2.839
$((y - y^*)/y^*)$	0.0046*	0.0012	3.7027
$(G_y - G_{y^*})$	-0.0179**	0.0096	-1.8649
Intercept	0.0462*	0.0095	4.8674
R-Squared	0.587		
Adjusted R-Squared	0.5312		
D.W. Statistics	1.7473		

Note:- The lower and upper limits of D-W statistics for 3 explanatory variables are : dL=1.480, dU=1.689. * significant at 1 percent level. ** significant at 10 percent level

The estimate of the coefficient of the expected rate of inflation β_1 is positive and significant. The numerical value of this coefficient is important because in the long run , even with adaptive expectations, it is found that actual rate of inflation and expected rate of inflation are equal if the value of β_1 is one. But the result suggests that the estimate of β_1=.3365 is significantly different from zero. It is also significantly different from 1. This suggests that there is a short run Phillips curve in India and there no evidence of long run Phillips curve to be vertical. The price or wage rates are not sticky and that there is a trade-off between inflation and unemployment.

Another import result is regarding the estimated value of $\beta_2.\beta_2$ represents the sensitivity of wages/prices to the labour market disequilibrium. Its value is positive and significantly different from zero rejecting the null hypothesis β_1=0 at 1 percent level of significance. Since it represents the degree of responsiveness of wage to the disequilibrium in the labour market, it determines the slope of simple Phillips cure and aggregate supply curve. The wages and prices are not rigid and that there is a short run Phillips curve and there is a trade-off between inflation and unemployment.

The wages and prices are not rigid unlike Keynesian case. But the fiscal and monetary policies are lively to have significant effects on the level of output and employment in the short run. They will have a effect on prices also. There seems to e a trade-off between inflation and unemployment.

Another important result of the present study is regarding negative and statistically significant estimate of β_3 in equation (8). It represents a combined effect of two parameters, h and q from equation (5) and (6). Parameters h represents the sensitivity of the rate of inflation to the rate of recovery(growth) in the economy, where as q is the Okun's parameter reflecting the cost of unemployment in excess the natural rate of unemployment. Since the Okun's coefficient q depends on the overall marginal productivity of labour in the whole economy, we can reasonably assume that it would be positive for any economy developed or underdeveloped.

Thus, the negative estimate for the coefficient β_3 implies that h is negative for the Indian economy. The strategy of rapid recovery or fast growth to reduce involuntary unemployment in the Indian economy is not likely to fuel inflationary prices. On the contrary, however, the strategy of slow recovery in likely to aggravate inflationary pressures I the Indian economy.

The well known argument that the Indian labour force in characterized by the phenomenon of disguise and under employment like most other developing countries and that a rapid rise in demand for labour, therefore, does not raise wages does not seem to hold good according to the present results. This, may be because of two reasons : First Indian is a democratic country and people or labour does hesitate. Despite presence of under employment and disguised unemployment, when the demand for a particular skilled labour increases, the pressure on wages increases as there are complementary among differently skilled labour.

4.3 Granger Causality Tests

The causality tests performed by application of E-views software are given in table (4.4).

Table: 4.4

Granger Causality Tests

Null Hypothesis	observations	F-statistic	Probability
((y – y*)/y*)does not Granger CauseInfl(GNPD)	55	3.722	0.031
Infl(GNPD) does not Granger Cause((y – y*)/y*)	55	1.376	0.262
(Gy – Gy*) does not Granger CauseInfl(GNPD)	55	2.915	0.064
Infl(GNPD) does not Granger Cause (Gy – Gy*)	55	6.923	0.002

The first row of above table shows that the null hypothesis, ((y – y*) / y*) does not Granger Cause Infl(GNPD), is rejected at 3.1 percent level of significance and therefore, output gap ratio ((y – y*) / y*) Granger causes Infl(GNPD). The null hypothesis, Infl(GNPD) does not Granger Cause ((y – y*) / y*), can't be rejected due to non-significance result as is evident from second row of the table. So, there is a unidirectional causal relationship between Output gap ration ((y – y*) / y*) and GNP Deflator based inflation rate. In other words the output gap ratio Granger causes the inflation and not vice versa.

The third row shows that the null hypothesis,(Gy – Gy*) does not Granger Cause Infl(GNPD), is rejected at 6.4 percent level of significance and therefore, (Gy– Gy*) Granger Causes Infl(GNPD). Similarly, it can be seen that the null hypothesis, Infl(GNPD) does not Granger Cause (Gy – Gy*), is rejected at 0.2 percent level of significance and a change in GNP Deflator based inflation effects the gap of output growth rate (Gy – Gy*). Hence, there is a bidirectional causal relationship between gap of output growth rate and GNP Deflator based inflation rate.

In other words, the gap of output growth rates Granger causes the GNP based inflation rate and GNP based inflation rate Granger causes gap of output growth rate i.e. there is a feedback or bidirectional causality relationship.

Conclusion of the Study

The study brings out the fact that the past studies have found mixed evidence about the shape of the Phillips curve from being horizontal to vertical. The researcher has also observed that there are very few studies about the developing countries including India. This may be attributed to the lack of availability of well defined, reliable and long run time series of data on unemployment. Similarly, evidence regarding the direction of causality between inflation and unemployment is also not conclusive.

To avoid meaningless or spurious regression all the variables used in the estimation of Expectation Augmented Phillips curve were tested for stationarity using Augmented Dickey- Fuller (ADF) test and Phillips-Parron unit root test. The variables test in levels as well as first difference. The hypothesis of the presence of unit root was rejected in all the cases by ADF test as well as PP- test. Therefore, the variables representing inflation, lagged inflation, output gap ratio and gap of output growth rates were found to be stationary.

The estimates of the model show that about 59 percent of the variation in inflation is explained by the model and the D-W statistic shows the absence of auto correlation.

All the coefficient are significant at 5 percent level except one which is significant at 10 percent level of significance. The present finding does not support the hypothesis of vertical Phillips curve. Rather it suggests that there is a short run Phillips curve in India. It is evident from the fact that the coefficient of lagged inflation or expected inflation is significantly less than one and different from zero.

Another important result is the estimated value of β_2, the coefficient of output gap ratio. This represents the sensitivity of price inflation to the labour market disequilibrium. It is positive and significant. Since it represents the degree of responsiveness of the wage or price to the labour market disequilibrium, it determines the slope of the simple Phillips curve. Thus, the wages and prices are not sticky and there is a short run Phillips curve. There is a trade-off between prices and unemployment.

Another important result of the study is a negative and significant estimate of β_3, the coefficient of gap of output growth rates. It represents the combined effect of h and q of equations 5 and 6 respectively. Since, q depends on marginal productivity of labour and can be assumed to be positive, h must be negative for the Indian economy. This shows that any policy aimed at rapid economy growth or recovery will not result in the rise of inflation. Rather it should reduce the involuntary unemployment. While, on the other hand, a slow recovery or lower growth rate may aggravate inflationary tendency in the economy. In sum, it can be said that India can reduce involuntary unemployment through faster and inclusive economic growth without facing the problem of inflation. But for that it must grow rapidly. Regarding the causation, the results show that the output gap ratio Granger causes the inflation but inflation does not Granger cause output gap ratio. Thus, there is only a unidirectional causation. But the gap of output growth rates Granger cause inflation and vice versa, i.e. inflation Granger causes gap of output growth rates. Thus, there is bidirectional causation between inflation and gap of output growth rates.

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