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SPEED OF ADJUSTMENT AND INFLATION – UNEMPLOYMENT TRADEOFF IN DEVELOPING COUNTRIES – CASE OF INDIA

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AMEY A. SAPRE[2]

Abstract

This paper estimates the short-run aggregate supply curve for the Indian economy over the period 1950-51 to 2008-09. Methodological improvements in this paper include the technique of estimating adaptive expectations, constrained estimation consistent with long run equilibrium, and introduction of the extended Phillips curve. The study also attempts to investigate the question of speed of recovery and the choice of adjustment paths available to policymakers in face of adverse supply shocks. Contrary to previous studies, the present study finds a regular tradeoff between inflation and output or unemployment with inflationary expectations based on the experience of past three to four years. We also find that the subtle tradeoff between the rate of output recovery and inflation is negative in India thereby implying that a strategy of fast recovery is not likely to result in high inflationary pressures.

Keywords: Extended Phillips curve, adaptive expectations, Indian economy, Growth-Inflation tradeoff, Aggregate Supply

JEL Classifications: E2, E24, E31, C22, D84

1. The Problem

In this paper, we examine the tradeoff between inflation and output growth in the Indian economy over the period 1950-2009. The objective is to estimate the short-run aggregate supply curve for India based on the inflation-unemployment tradeoff and to address the issues of inflationary expectations, strategy for dis-inflation and recovery on the supply side. These issues of late have been very relevant in several developed and developing economies. The inverse relationship between inflation and unemployment underlying the Phillips curve provides the basis for the stance of fiscal and monetary policies to control inflation by sacrificing growth of the economy. Policy makers also often presume that disinflation requires the economies to slow down postponing their recovery, Government of India (2011). However, before deciding, it is pertinent to test these hypotheses about the tradeoffs.

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It is well recognized by now that the tradeoff between inflation and unemployment is essentially a short-run phenomenon. The expectation augmented Phillips curve as argued by Phelps (1967) and Friedman (1968) shows that unemployment would remain at its natural rate irrespective of the rate of inflation in the long run because of expectations about inflation. The basic choice before the policymaker is, however, in terms of selecting alternate adjustment paths that differ in the inflation-unemployment mix in face of adverse supply shocks or in strategies for dis-inflating the economy, for instance see Dornbusch and Fischer (1990). To capture this, the Phillips curve should ideally be extended with introduction of changes in unemployment rate and hence the speed of recovery of the economy. The argument is that inflation depends not only on the expected inflation rate and the level of unemployment, but also on the change in the unemployment rate over time, because rapid reduction in unemployment rate immediately puts upward pressure on wages leading to higher inflation. Thus, rapidly falling or sharply increasing unemployment becomes an important consideration in deciding about policies for dis-inflation and strategy for recovery.

The question of high inflation and unemployment has recently become important during the post-crisis phase with a renewed attention of academia, policy and socio-political debates in the Indian economy. Before the financial crisis of 2008, the Indian economy grew rapidly for three consecutive years clocking the annual rate of growth of real GDP in excess of 9 percent. The financial crisis halted this momentum and the economy considerably slowed down to a growth rate of about 6.7 percent. India's Economic Survey, Govt. of India (2011) highlights that post-crisis, during the last two years, the economy made a strong recovery to regain its high growth rate but experienced severe pressure of high inflation. Such a situation was thought to be due to the speed of recovery of the economy, though the recovery in the sense of returning to high growth path is not complete yet. The Survey further states that in designing inflation control measures at this stage, policy induced demand contractions can cause unemployment to rise. It implicitly assumes not only the regular tradeoff between inflation and unemployment but also the subtle tradeoff between speed of recovery and inflation involved in the choice of alternate adjustment paths to achieve sustained recovery with low inflation. Thus, India represents a perfect case to investigate such tradeoffs.

In the Indian context, major efforts have been to search for the existence of the conventional Phillips curve implying regular tradeoffs between inflation and unemployment or inflation and output. The question of speed of recovery and choice of adjustment path as captured by the extended part of the Phillips curve has largely remained unexplored. It is imperative to test these hypotheses and get the estimates of tradeoffs for meaningful policy measures during the process of recovery and dis-inflation. The present paper makes an attempt in this direction using the data over the period 1950 to 2009. In the process, we develop a theoretical framework for estimating the extended Phillips curve, model inflationary expectations using adaptive expectations and develop the criteria for selecting the most appropriate equation for evaluating the hypothesis.

The paper is organized as follows: section 2 presents the findings of some important previous studies on inflation-output/employment tradeoff in India and briefly discusses why the situation could significantly be different in a developing country like India from the one in a developed country. Section 3 develops the framework for the regular and extended Phillips curve;

Section 4 discusses the formulation of inflationary expectations; Section 5 reports the empirical results and section 6 concludes the discussion with policy implications.

2. Earlier findings and the hypothesis

Studies for India that address the tradeoff includes Rangarajan (1983) who initially examined the price and output changes in the industrial sector and concluded that the relationship between inflation and unemployment, if at all, was positive. Rangarajan and Arif (1990) estimated an econometric model to investigate the interrelations between money, output and prices. They evaluated the tradeoff between output and prices and showed that government capital expenditure increases output but leads to higher prices. The tradeoff between output and inflation worsens sharply as the resource gap is met by borrowings from the Reserve Bank. Dholakia (1990) examined the tradeoff between inflation and output within the Phillips curve framework by estimating the short-run aggregate supply curve for the period 1950-51 to 1984-85. He found no substantial tradeoff in the economy in the short run, implying almost rigid wages and prices in the short-run as in the Keynesian case. Taking the monetary policy stance, Singh and Kaliranjan (2005) empirically explored the inflation - growth nexus to estimate the threshold inflation rate for India. Like earlier studies, they did not find any serious tradeoff between inflation and growth in India. On the contrary, they found that an increase in inflation from any level would have a negative effect on growth.

Most of the studies on the tradeoff between inflation and output or unemployment for the Indian economy have not addressed formation of inflationary expectations adequately. The methodology of using distributed lags for forming adaptive expectations initially popularized by Cagan (1956) and Nerlove (1958) and skillfully used by Turnovsky (1970, 1972) and Laidler (1976, 1977) forms the basis for our consideration. However, it cannot help is in estimating the number of past years of inflationary experience people are effectively using to from their current expectations. We modify the method of considering adaptive inflationary expectations method to provide such an estimate. Following the discussion of the basic framework in the next section, we discuss the procedure for formation of inflationary expectations in section 4.

The question about the number of years of past experience effectively considered by people to form inflationary expectations in the current year may prove to be important because a developed country and an underdeveloped country could differ significantly in this regard. In a developed economy, the speed of adjustment of wages to the labor market disequilibrium may be extremely high implying a smaller number of years for considering inflationary expectations. In a developing economy, such adjustments could be slow implying a larger number of years for effectively considering formation of inflationary expectations. This is likely to happen in developing countries like India because developing countries by their very nature do not have well-developed and efficient labor markets. Moreover, the concept of unemployment is not uni-dimensional in such countries because of pre-dominance of rural areas, agriculture and informal sectors. For India, the Dantwala Committee had raised the structural and dimensional problems in measuring the magnitude of employment and unemployment, Government of India (1970). It had clearly indicated that it would not be justified to aggregate the labor force, employment and unemployment into single-dimensional magnitudes in view of inherent socioeconomic conditions prevailing in the country. Since the 1970s, the detailed quinquennial National Sample Surveys have been reflecting the multi-dimensional features of employment-unemployment in the country. However, despite such efforts, the measures presently in use have not been found to capture the complex characteristics of quality and volume of employment and unemployment in the economy, Krishnamurthy and Raveendran (2008). As a result of such complexity present in the developing countries, the link between disequilibrium in the labor market, wages and hence prices as postulated in the Phillips curve hypothesis could be non-existent, or at best, very weak as found in several studies on India discussed earlier.

Paul (2009) attempting to find the Phillips curve argued that earlier studies could not get a regular Phillips curve in India because they did not adjust for exogenous factors like droughts, oil shocks and liberalization policy. He demonstrated that a short-run Phillips curve did exist for India in the industrial sector once these factors were included as dummies in the equation. Patra and Ray (2010) empirically explored the relationship between inflationary expectations and the monetary policy. They estimated a Phillips curve taking into account fiscal and monetary policy stance, marginal costs and supply shocks. Their finding is consistent with the adaptive expectation hypothesis that high inflation seeps into anticipation of future inflation and tends to linger. Given the output and inflation tradeoff, it may be contended that the basic problem of developing countries is to achieve high growth in the face of under or un-utilized potential. In other words, it suggests that developing countries would not experience inflationary pressures if the pace of growth is high. This is because, apart from sluggish and inefficient labor markets in these countries, a large part of their growth is on account of increased productivity resulting from reallocating the resources or re-organization of activities. On the contrary, such pressures would be high if the pace of growth is slow. Such an expectation is in sharp contrast to the hypothesis of the extended Phillips curve and calls forth an empirical investigation especially for the developing economies.

3. Framework

Conventionally, the Phillips curve augmented for 'expectations' of inflation represents the tradeoff between inflation and unemployment in an economy in the following way:

$$gp_t = gpe_t - \beta(u_t - \bar{u}) + \varepsilon \qquad \text{... (1)}$$

where, (gp) is actual inflation rate, (gpe) is expected inflation rate, ($u - \bar{u}$) is cyclical unemployment given by the difference of unemployment rate (u) and natural rate of unemployment ($\bar{u}$) and (ε) is an error term. The parameter (β) measures the response of inflation to cyclical unemployment. The distance between (u) and ($\bar{u}$) is called the unemployment gap. In case, the unemployment gap is positive (i.e. $u > \bar{u}$), the augmented Phillips curve given by equation (1) implies that the actual inflation rate is less than the expected inflation rate. For the Indian economy, as in the case of most of the developing economies, comparable and reliable long time series data on unemployment rates do not exist. It is, therefore, necessary to convert equation (1) by using the alternative formulations to proxy unemployment over time. An assumption of either the short-run aggregate production function or the Okun's Law makes it possible to substitute unemployment over time by output. Okun's Law states that, deviation of output from its trend rate is inversely related to deviations of unemployment from its natural rate (Okun 1983; Mankiw 2006). This is an empirical finding given the status of a 'law' like the original

Phillips curve. It is possible to derive such a relationship if we assume a simple proportional short-run production function. Using this relation, we can convert the second term of equation (1) using the definition of u as follows

$$-\beta(u-\bar{u}) = \alpha.\left(\frac{Y-\bar{Y}}{\bar{Y}}\right) \qquad \text{... (2)}$$

where Y and Y-bar are output and trend level of output respectively; and α is β times the ratio of trend level of output and full employment level of output.

With this substitution, the Phillips curve equation can now be written as:

$$gp = gpe + \alpha.\left(\frac{Y-\bar{Y}}{\bar{Y}}\right) + e \qquad \text{... (3)}$$

The hypothesis of the Phillips curve can be empirically tested by using equation (3) by making use of price and output data. However, it is appropriate here to introduce the theoretical underpinnings of the extended part of Phillips curve. The theory of the extended Phillips curve introduces the question of alternate adjustment policy paths. It refers to the choices available to policymakers in the face of adverse supply shocks and disturbances that create both high inflation and high unemployment. The policy choice is between a fast recovery of output and employment and a gradualist disinflation policy. Okun's law suggests that reducing unemployment would require a sustained high growth strategy. However, the extended part of the Phillips curve indicates that a strategy for fast reduction of unemployment would lead to inflationary pressures in the economy. These perspectives indicate the dilemmas in the policy choice of alternate adjustment paths. Formally, in order to capture the effect of the speed of recovery, the Phillips curve is extended to include the term $\varphi(u_t - u_{t-1})$, which represents the change in unemployment over time. The extended Phillips curve is now written as:

$$gp_t = gpe_t - \beta(u_t - \bar{u}) - \varphi(u_t - u_{t-1}) + \varepsilon \qquad \text{... (4)}$$

which includes current (u_t) and past period's unemployment rate (u_{t-1}). It indicates that current inflation depends on expected inflation, unemployment gap and the speed at which unemployment changes. The parameter (φ) measures the extent to which changing unemployment affects inflation. A larger value of (φ) signifies a greater importance of the effect of changing unemployment on the inflation rate. The parameter, thus, represents the sensitivity of wages and the rate of inflation to the rate of recovery in the system. Further, using a proportional short-run production function we can rewrite the third term in equation (4) as

$$u_t - u_{t-1} = \frac{Y_{t-1}}{Y_F}\left[\frac{Y_F}{Y_{F-1}} - \frac{Y}{Y_{t-1}}\right] \text{ or } u_t - u_{t-1} = \frac{Y_{t-1}}{Y_F}\left[1 + G_{\bar{Y}} - 1 - G_{Y_t}\right]$$

which can be written in terms of growth rates of variables as:

$$u_t - u_{t-1} = -\left[\frac{1}{q}\right].\left(G_{Y_t} - G_{\bar{Y}}\right) \qquad \text{... (5)}$$

Where Y_{t-1} is output in the last period, $q=Y_F/Y_{-1}$ (which is closely akin to the Okun's Law), and G_Y and $G_{\bar{Y}}$ are growth rate of output and trend growth rate respectively. Using equations (3), (4) and (5) the extended Phillips curve can be written as:

$$gp = gpe + \alpha\left(\frac{Y-\bar{Y}}{\bar{Y}}\right) + \left[\frac{\varphi}{q}\right].\left(G_Y - G_{\bar{Y}}\right) \qquad \text{... (6)}$$

We now have the basic Phillips curve given by equation (3) and the extended Phillips curve given by equation (6). These equations can be estimated using only price and output data. However, in order to empirically estimate equation (3) and (6) we need first to define the expected inflation (*gpe*).

4. Formation of Inflationary Expectations

In defining and testing the expectations hypothesis, the formal approach has been to use variants of the adaptive expectations framework. These continue to be theoretically the most accepted and convenient frameworks for integrating inflationary expectations into the Phillips curve. It has also been a common practice to formulate the expectation of inflationary process as similar to the one used for measuring permanent income, see for instance, Friedman (1957) and Dernburg (1985). One of the problems in formulating and testing the expectations hypothesis is that no direct price expectations data are available for most developing countries. For developed countries, direct data on price expectations are available and have been used to test the expectations hypothesis, Turnovsky (1972). But in the case of developing countries, testing of such hypotheses requires either consideration of lagged inflation or construction of expected inflation series based on past observed inflation rates. This leads to several choices of models that can generate expectations based on actual past values of the variable and in turn, calls for a test of hypothesis of expectations coming true in the long run.

Turnovsky (1970, 1972), Laidler (1976, 1977) and Trivedi (1980) are among the early efforts to model adaptive expectations and discuss the strategy for estimation. Recent studies have used alternative frameworks, see for instance, Patra and Ray (2010) such as the ARMA process on monthly data for estimating inflationary expectations. However, their method has the limitations that it does not offer any test of hypothesis about expectations coming true on an average in the long run, which is a pre-requisite for existence of the long run equilibrium. As Turnovsky (1972) argues, a test of such a hypothesis is essential because the underlying expectations could be generated by several alternate mechanisms. Following the conventional methodology as in Laidler (1976), it is empirically more appropriate to use the adaptive expectations framework and to obtain a test of hypothesis about expectations coming true in the long run. This would ensure a theoretically consistent and statistically tested result meaningful for interpretation. We, therefore, postulate that expectations of inflation are based on current and past inflation rates. Thus, expected inflation (gpe_t) would be equal to last period's expectation of current inflation rate (gpe_{t-1}) plus some fraction (*v*) of the deviation of the current period (actual) inflation rate from the expected rate of the last period. Formally, this is given by the adaptive process:

$$gpe_t = gpe_{t-1} + v\left(gp_t - gpe_{t-1}\right) \text{ or } gpe_t = v.gp_t + \left(1-v\right)gpe_{t-1} \qquad \text{... (7)}$$

where (v) is the coefficient of adjustment of the adaptive process. Equation (7) applies to all time periods taking different values of (t) and sequential substitution gives the standard expression:

$$gpe_t = vgp_t + v\left(1-v\right)gp_{t-1} + v\left(1-v\right)^2 gp_{t-2} + ...v\left(1-v\right)^r gpe_{t-r}$$

or alternatively,

$$gpe_t = v.\sum_{r=0}^{\infty}(1-v)^r.gp_{t-r} \quad ... (8)$$

The equation represents the expected rate of inflation as a weighted average of all past observed (or actual) inflation rates. Thus, all past values of inflation (gp) have to be considered to estimate expected inflation (gpe) unless (v) takes extreme values of either (0) or (1). In the former case for (v) = 0, the expectations are completely inelastic or fully non-adaptive while for (v) =1 expectations are infinitely elastic or instantaneously adaptive, implying rational expectations. The parameter (v) is crucial for estimation purposes since its value has implication about the alternate hypothesis of formation of expectations.

While examining the demand for money in India, Trivedi (1980) using the adaptive expectations method generated alternate series of expected inflation by varying the values of (v) at a regular interval of 0.1 between (0) and (1). In order to make a back series, he assumed the value of expected inflation to be equal to the actual inflation upto the initial year arbitrarily selected from the past and constructed the series by varying the values of (v). However, this assumption introduces unknown degree of errors in the calculation on account of assuming the initial value of expected inflation and varying (v) at a regular interval. It is possible to replace this assumption with a more plausible and defensible one for generating alternate series of expected inflation. It is clear from equation (8) that there is a definite unique relationship between the value of (v) and the number of periods (r) contributing substantially to the formation of inflationary expectations in the current period. However to ascertain this we need to decide on a decimal value that can be considered as approximately equal to unity. When we assume 0.995 as approximately equal to unity, and because weights decline geometrically over time, it implies ignoring all distant years whose cumulative total importance in forming today's expectation does not exceed 0.005 or 0.5%. This method has the advantage over the existing alternative method of Trivedi (1980) in the way that it can help us determine the number of years of past inflation people consider effectively to form inflationary expectations. With this approximation, we can determine a precise relationship between the two parameters (r) and (v) such that, given one of the parameters the other can be computed.[1] The precise relation is:

$$v = 1-(0.005)^{\frac{1}{(r+1)}} \quad ... (9)$$

However, (r) has certain integer constraints since availability of data is for a definite unit of time rather than on a continuous basis. Empirically, it would be appropriate to fix the value of (r) and obtain the implied value of (v). Numerically this implies:

$v = 1-(0.005)^{\frac{1}{(r+1)}}$ for r =1,2….t. Thus for r =1,

$v_{r=1} = 1-(0.005)^{\frac{1}{(1+1)}} = 0.9293.$ Substituting for all values of r=1,2,3….20, we have the following table for corresponding values of (r) and (v).

Table 1. Values of (r) and Corresponding Values of (v)

r	*v*	*r*	*v*	*r*	*v*	*r*	*v*
1	0.9293	6	0.5309	11	0.3569	16	0.2678
2	0.8290	7	0.4843	12	0.3347	17	0.2550
3	0.7341	8	0.4450	13	0.3151	18	0.2434
4	0.6534	9	0.4113	14	0.2976	19	0.2327
5	0.5865	10	0.3822	15	0.2819	20	0.2230

Table 1 shows all possible values of (v) as we consider increasing number of past accounting for the 99.5% of the formation of current inflationary expectations. Using these values, we can construct alternate series of inflationary expectations (gpe) by taking into account only current and past inflation rates. In each of the iterations, the number of observations would decrease as the value of (r) increases in equation (8). Based on this we generate 10 alternate series of inflationary expectations using the values of (r) from 1 to 10.

The methodology adopted here is operationally different from Trivedi (1980). As mentioned, he assumed an initial value of the difference between the expected inflation and the observed inflation rate as zero and constructed alternate series of inflationary expectations with different values of (v) at a regular interval of 0.1. In contrast, it may be argued that making an approximation of unity for the purpose of calculating the values of (r) and (v) is empirically more appropriate as it imposes lesser constraints on parameters for calculation. Further, it also does not make any approximation about the initial value of expected inflation for generating a series. We can now estimate the Phillips curve and the extended Phillips curve equations for each alternate series of expected inflation based on different values of (r) and (v) and discuss the procedure for testing the hypothesis, results, and their implications in the following sections.

5. Estimation and Results

As derived previously, we first estimate the regression equation representing the conventional Phillips curve -

$$gp_t = \beta_0 + \beta_1 gpe_t + \beta_2 \left(\frac{Y-\bar{Y}}{\bar{Y}}\right)_t + \varepsilon \qquad \text{... (10)}$$

where, gp is actual inflation, gpe is expected inflation, $(Y-\bar{Y})/\bar{Y}$ is output gap, β_i's are regression parameters and (ε) is an error term. The data used for estimation is the series of India's annual Gross Domestic Product (GDP) at factor cost from 1950-51 to 2008-09 at 1999-2000 (constant) prices. The rate of annual inflation is calculated using the GDP deflator. The trend growth rate of output is calculated by fitting a log-linear trend line to GDP series and the deviation of actual annual growth rate from the trend growth rate is calculated accordingly. As earlier mentioned, ten alternate series of inflationary expectations are generated with values of (r) ranging from 1 to 10, with corresponding values of (v) ranging from 0.9293 to 0.2550 as per table 1, and equation (10) would be estimated for all the ten alternate series of expected inflation.

Before we proceed, we need to address two issues pertaining to specification of models. The first is of inclusion or exclusion of the intercept in the equation. Laidler (1976) discusses the issue at length for meaningful interpretation of the equation. He observes that for evaluating the hypothesis in the Phillips curve framework, the intercept would be either constrained to zero or entirely omitted. Laidler argues that if there is no un-explained trend in prices, the intercept should be zero. This implies that the Phillips curve equation can be estimated by omitting the intercept thereby constraining the equation to pass through the origin.

The second issue is what Paul (2009) raised about including exogenous influences like supply shocks and policy regime change. He cites several studies in support to argue that adverse supply shocks are amongst the most important factors in explaining fluctuations in inflation in India. He considers three shock variables namely; drought, oil shock and liberalization policy as factors contributing to the explanation of inflation in India. The dummy for drought is constructed by taking into account years of 1965, 1966, 1972, 1979, 1982, 1987, and 2002 and assigning one to each post drought year and zero otherwise. The oil shock dummy is built on the basis of Abel and Bernanke (2008) by considering two adverse supply shocks that stand out, namely 1973-74, 1979-80 and a third one in 1990. The dummy is assigned as one for two consecutive years following the first and second oil shock and one after the third oil shock. The liberalization policy dummy is constructed by taking years of 1992-1995 as one, and zero otherwise. However, Paul (2009) considers all the three variables as the intercept dummies that are contrary to Laidler's (1976) argument of omitting the intercept. Since we consider the inclusion of shock variables, we introduce slope dummies instead of intercept dummies to omit the intercept. We follow a stepwise process, re-examine the results by dropping the insignificant shock variable, and report the results of those that were found to be statistically significant. Considering these two aspects of shock variables and omitting the intercept, the equation to estimate the Phillips curve is:

$$gp_t = \beta_1 gpe_t + \beta_2 \left(\frac{Y-\bar{Y}}{\bar{Y}}\right)_t + \beta_{3i} D_{it} \left(\frac{Y-\bar{Y}}{\bar{Y}}\right)_t + \varepsilon \qquad \text{... (11)}$$

where D_{it} is the dummy for the i^{th} shock variable and β_{3i} is the corresponding correction in the slope parameter, β_2 due to i^{th} shock variable. We estimate equation (11) accordingly for all 10 alternate series of inflationary expectations. In order to select the most appropriate regression, we choose the one that fulfills all of the following criteria such that it confirms to the theoretical formulation: (i) (β_1)=1,[2] (ii) DW statistic[3] not showing autocorrelation and (iii) subject to conditions (i) and (ii) maximum adjusted R^2. The estimates of equation (11) for all 10 alternate series of expected inflation, excluding the intercept but with a slope dummy for the oil shock are presented in table 2.

Table 2 shows the results of the Phillips curve (equation 11) with a slope dummy for adverse oil shocks. The other two shock variables namely drought and liberalization policy were not statistically significant and hence dropped. The results show that the coefficient of output gap (β_2) is positive but insignificant in all the ten equations. It represents the responsiveness of wages to the disequilibrium in the labor market and hence determines the slope of the simple Phillips curve and the aggregate supply curve. The results can be interpreted to imply that the economy has almost a horizontal Phillips curve indicating that there exists no substantial tradeoff between inflation and unemployment in the short run. The coefficient of the slope dummy for the oil shock variable is negative and statistically significant in all equations except the first two. Similarly, the coefficient of expected inflation is significantly not different from unity in all except the first two regressions. As derived previously, the selection criterion for the best equation in the framework of the Phillips curve is: highest adjusted R^2 subject to fulfilment of the condition of lack of autocorrelation, and $\beta_1 = 1$.

Table 2. Regression Results of the Phillips Curve in India

S. No	*gpe*	*Y gap*	*Y gap. *D (oil shock)*	*Adj R^2*	*DW*	*N*	*v*
1	1.016 SE (0.007) $(t)_{b=1}$ (2.285)*	0.324 SE (0.453) t val (0.770)	-1.278 SE(0.179) t val (-0.816)	0.998	2.410	57	0.9293
2	1.026 SE (0.016) $(t)_{b=1}$ (1.625)#	1.122 SE (1.099) t val (1.020)	-5.278 SE(.3743) t val (-1.410)	0.990	2.240	56	0.8290
3	1.027 SE (0.025) $(t)_{b=1}$ (1.080)	1.542 SE (1.702) t val (0.896)	-10.337 SE(5.665) t val (-1.825)#	0.978	1.959	55	0.7341
4	1.017 SE (0.030) $(t)_{b=1}$ (0.566)	2.791 SE (2.091) t val (1.335)	-17.622 SE(6.854) t val (-2.571)*	0.967	1.883	54	0.6534
5	1.014 SE (0.036) $(t)_{b=1}$ (0.388)	3.085 SE (2.470) t val (1.249)	-22.680 SE(7.971) t val (-2.854)*	0.955	1.718	53	0.5865
6	0.990 SE (0.035) $(t)_{b=1}$ (-0.285)	1.832 SE (2.429) t val (0.754)	-27.510 SE(7.666) t val (-3.588)*	0.956	1.769	52	0.5309
7	0.988 SE (0.038) $(t)_{b=1}$ (-0.315)	2.129 SE (2.656) t val (0.801)	-31.127 SE(8.311) t val (-3.745)*	0.949	1.726	51	0.4843
8	0.984 SE (0.042) $(t)_{b=1}$ (-0.380)	2.275 SE (2.882) t val (0.790)	-34.311 SE(1.016) t val (-3.858)*	0.942	1.679	50	0.4450
9	0.981 SE (0.044) $(t)_{b=1}$ (-0.431)	2.421 SE (3.075) t val (0.787)	-37.065 SE(9.411) t val (-3.983)*	0.936	1.644	49	0.4113
10	0.979 SE (0.047) $(t)_{b=1}$ (-0.446)	2.581 SE (3.260) t val (0.791)	-39.451 SE(9.866) t val (-3.999)*	0.930	1.609	48	0.3822

Note: gpe is expected inflation, Ygap is output gap, D is a slope dummy for oil shock as defined earlier, SE is standard error of parameter, DW is Durbin-Watson statistic (see endnote 3), N is number of observations and (v) is the coefficient of adaptive expectation. (*) indicates value significant at 1%, (**) indicates significance at 5%, (#) indicates significance at 10% level, $(t)_{b=1}$ is (t) value for the null hypothesis, $ß_1$=1.

All equations except the first one are consistent with the null hypothesis of lack of autocorrelation. Considering these aspects, equation (3) in table 2 fulfills all requirements of having the maximum adjusted R^2 (0.978) subject to fulfilling the condition of lack of autocorrelation and coefficient of expected inflation being statistically not different from unity. The estimates of parameters of equation (3) in table 2 indicate lack of any significant tradeoff between inflation and unemployment or output in the Indian economy. This finding is consistent with all previous studies on India. Paul (2009) who argued for incorporating exogenous shock variables also did not find a regular positive tradeoff between output and inflation even after adjusting for supply shocks. He could find the regular Phillips curve only for the industrial sector in India after adjusting the time period from fiscal year to crop year. Thus, it is not the exogenous supply shocks that play a crucial role in finding the regular inflation-output tradeoff in developing countries like India.[4] We have to search for other influences in investigating the tradeoff. The inflation-unemployment tradeoff in its entirety requires the framework of the extended Phillips curve as discussed earlier. The extended part of the Phillips curve modifies the basic Phillips curve to equation (6) above. Incorporating the slope dummies for the supply shock variables gives the following equation for estimation:

$$gp_t = \beta_1 gpe_t + \beta_2 \left(\frac{Y-\bar{Y}}{\bar{Y}}\right)_t + \beta_{3i} D_{it} \left(\frac{Y-\bar{Y}}{\bar{Y}}\right) + \beta_4 \left(G_Y - G_{\bar{Y}}\right)_t + \varepsilon \qquad \text{... (12)}$$

where $\left(G_Y - G_{\bar{Y}}\right)$ is the growth gap and remaining variables are the same as before. As previously discussed, the equation is estimated by omitting the intercept and by following a stepwise process of dropping the insignificant shock variable. The results of the regression equation (12) for all 10 series of alternate inflationary expectations are presented in table 3.

Table 3. Regression Results of the Extended Phillips Curve Equation in India

S. No	*gpe*	*Y gap*	*G_Y-$G_{\bar{Y}}$*	*Ygap*D(oil shock)*	*Adj R^2*	*DW*	*N*	*v*
1	1.019 SE (0.006) $(t)_{b=1}$ (3.166)*	0.694 SE (0.456) t val (1.521)	-0.036 SE (0.015) t val (-2.457)**	-0.462 SE(1.534) t val (-0.301)	0.998	2.454	57	0.9293
2	1.034 SE (0.015) $(t)_{b=1}$ (2.666)**	2.046 SE (1.104) t val (1.854)#	-0.091 SE (0.035) t val (-2.591)**	-3.197 SE(3.645) t val (0.877)	0.991	2.306	56	0.8290
3	1.041 SE (0.024) $(t)_{b=1}$ (1.708)#	2.934 SE (1.710) t val (1.718)#	-0.138 SE (0.054) t val (-2.552)**	-7.118 SE(5.533) t val (-1.287)	0.980	2.011	55	0.7341
4	1.036 SE (0.029) $(t)_{b=1}$ (1.241)	4.704 SE (2.081) t val (2.261)**	-0.182 SE (0.065) t val (-2.791)*	-13.387 SE(6.615) t val (-2.024)**	0.970	2.008	54	0.6534
5	1.037 SE (0.035) $(t)_{b=1}$ (1.057)	5.352 SE (2.491) t val (2.149)**	-0.204 SE (0.078) t val (-2.626)*	-18.052 SE(7.742) t val (-2.332)**	0.960	1.788	53	0.5865
6	1.015 SE (0.034) $(t)_{b=1}$ (0.441)	4.284 SE (2.416) t val (1.773)#	-0.216 SE (0.074) t val (-2.901)*	-22.617 SE(7.341) t val (-3.081)*	0.962	1.688	52	0.5309
7	1.024 SE (0.037) $(t)_{b=1}$ (0.648)	5.478 SE (2.635) t val (2.079)**	-0.274 SE (0.084) t val (-3.257)*	-24.793 SE(7.832) t val (-3.166)*	0.958	1.676	51	0.4843
8	1.022 SE (0.040) $(t)_{b=1}$ (0.550)	5.720 SE (2.861) t val (2.001)**	-0.287 SE (0.091) t val (-3.146)*	-27.728 SE(8.420) t val (-3.293)*	0.951	1.614	50	0.4450
9	1.025 SE (0.043) (t)b=1 (0.581)	6.313 SE (3.066) t val (2.059)**	-0.312 SE (0.098) t val (-3.137)*	-29.935 SE(8.890) t val (-3.367)*	0.950	1.601	49	0.4113
10	1.024 SE (0.045) (t)b=1 (0.533)	6.489 SE (3.259) t val (1.991)**	-0.318 SE (0.014) t val (-3.049)*	-32.227 SE(9.371) t val (-3.439)*	0.941	1.564	48	0.3822

Note: gpe is expected inflation, Ygap is output gap, G_Y and G $\bar{Y}$ are growth rates of actual and trend output, D is a dummy for oil shock as defined earlier, SE is standard error of parameter, DW is Durbin-Watson statistic (see endnote 3), N is number of observations and (v) is the coefficient of adaptive expectation. (*) indicates value significant at 1%, (**) indicates significance at 5%, (#) indicates significance at 10% level, $(t)_{b=1}$ is (t) value for the null hypothesis of $\beta_1 = 1$.

The result shows estimates of the extended Phillips curve equation with a slope dummy for adverse oil shocks. As previously, in all iterations the other two shock variables namely, drought and liberalization policy were statistically insignificant, and hence omitted. With the retained variables, the results have notably improved to show the positive and significant coefficient of output gap and the negative and significant estimate of the growth gap. This clearly shows that the regular Phillips curve implying the basic inflation-unemployment tradeoff for the whole economy has emerged once the extended part is included in the estimation. The coefficient of output gap (β_2) is statistically significant in all but the first equation and thus gives a definite evidence of a regular basic tradeoff between inflation and unemployment.

The parameter (β_3) representing the sensitivity of inflation rate to the rate of recovery turns out negative and significant for all regressions without exception. The negative sign of the coefficient is an important finding of the present empirical exercise. The coefficient of expected inflation is statistically different from unity in the first three out of the ten equations. The oil-shock slope dummy is negative and significant in all except the first three equations in table 3. The table also reveals a clear declining pattern of adjusted R^2 value as the number of years effectively considered by people to form inflationary expectations (r) increases from 1 to 10 and as corresponding values of (v) declines from 0.9293 to 0.3822. In order to select the best regression, we follow the same selection procedure as discussed earlier and identify equation (4) in table 3 as the best fit for the extended Phillips curve. The equation has the highest adjusted R^2 (0.970) amongst all those equations satisfying the condition of the long run equilibrium, i.e. coefficient of (gpe) statistically not being different from unity. Therefore, our estimate of the number of years effectively used by people to form inflationary expectations in India is about four years. Correspondingly, the speed of adjustment in correcting expectations is 0.6534.

The coefficient of (Ygap) is positive (4.7) and statistically significant at 5 percent. It represents the degree of responsiveness of wages to the disequilibrium in the labor market and hence determines the slope of the Phillips curve and the short-run Aggregate Supply (AS) curve. Our finding gives an upward sloping AS curve between inflation and output indicating a theoretically expected usual tradeoff between inflation and unemployment in the Indian economy. This finding differs sharply from all previous studies on India that did not find the regular tradeoff. The only study that incorporated the extended part of the Phillips curve, Dholakia (1990) had found a horizontal AS curve implying no tradeoff. Since the time period considered in his study was 1950-84, out finding here shows an emergence of a tradeoff as the economy moved into the liberalized era. The difference is highlighted by the fact that over time the economy has moved from an inward looking and controlled regime to trade oriented liberalized policies and market determined prices. With the integration to international markets, inflation is no longer driven exclusively by domestic factors and demand, but the supply side has also become responsive to market prices.

Our second finding is the statistically significant negative estimate of the coefficient of growth gap $(G_Y - G_{\bar{Y}})$. This represents the combined effect of two parameters (φ) and (q) from equations (2) and (4) in the text. Parameter (φ) represents the sensitivity of the rate of inflation to the rate of recovery (growth) of the system, whereas (q) represents the Okun's parameter reflecting the cost of unemployment in excess of the natural rate of unemployment. As shown in equation (4) in the text, the Okun's parameter given as a ratio of full employment output and the actual output in the last period would always be positive for any economy. Thus the negative estimate of the β_3 coefficient implies that parameter (φ) is negative for the Indian economy. This suggests that a strategy for fast growth to reduce involuntary unemployment is not likely to generate inflationary pressures in India. On the contrary, slow recovery is likely to aggravate inflationary pressures in the economy. On the other hand, both the fiscal and monetary authorities in India have been expressing a concern, though without any supporting empirical evidence, that rapid recovery may lead to inflationary pressures in the economy, Government of India (2011) and Reserve Bank of India (2011). Correspondingly, the current monetary policy stance has been firmly anti-inflationary, recognizing that under prevailing circumstances, some short-run deceleration in growth may be unavoidable in bringing inflation under control, Reserve Bank of India (2011). These arguments presuppose the regular inflation-unemployment tradeoff based on the basic Phillips curve, which is corroborated by our finding. However, their inference about the subtle tradeoff between speed of recovery and inflation from the basic Phillips curve is incorrect and is not supported by our findings. As per our finding, in order to control high inflation, a policy induced demand contraction is likely to result in a slower rate of recovery (growth) of the economy, which may be counter-productive for controlling inflation in India.

The third implication is that formation of inflationary expectations in India considers a weighted average of past four years of inflation experience. This by itself is a long period indicating sluggishness of wage and price adjustment in the economy. In the light of findings of Dholakia (1990), it is interesting to note that the underlying behavior and structure of formation of inflationary expectation has not undergone any substantial changes over time in India. Consideration of about four years of past inflationary experience in formation of expectations about the future has remained a predominant feature in the economy. The present exercise also shows that the adaptive process, as applied, provides theoretically consistent and empirically valid results for meaningful interpretation. The result about the speed of adjustment of expectations (v=0.65) with a period of four years for forming inflationary expectations indicates that the labor market in India is highly segmented and dominated by long term informal contracts. In other developing countries also, this is likely to be the case. As a result, rapid recovery is not likely to create upward pressure in wages (on average) and become costly in such economies. On the contrary, rapid recovery would lead to better utilization of the hitherto un/underemployed resources and augment the supply of output to bring down inflation. Unlike the case of developed countries, where the speed of adjustment of expectations is likely to be high because of unionized labor markets, the developing countries do not experience this subtle tradeoff between the speed of recovery and inflation also because they are relatively labor abundant.

Finally, the negative and statistically significant coefficient for the slope dummy for the oil shock suggests that such shocks essentially reduce the sensitivity of wages and price to the unemployment or the labor market disequilibrium in developing countries like India. Supply shocks make wages and prices more rigid and make the process of automatic adjustment towards equilibrium slower and painful in such economies. As per our results, under such circumstances, any measures of demand contraction like tight fiscal and monetary policies would result in larger unemployment for longer duration and in slower reduction in inflation. The implication of this finding is consistent with our other findings that the policy of fast (growth) recovery is the best option for the developing countries like India to solve their problems of both inflation and unemployment created by adverse supply shocks without worrying unduly about the tradeoff. Such subtle tradeoff between the speed of recovery and inflation would exist, if at all, in the developed countries and not in developing countries.

6. Conclusion

The study attempts to answer the question whether a tradeoff exists between inflation and unemployment in India. We empirically estimate the Phillips curve for India, subsequently incorporate the extended part of the Phillips curve, and find that a tradeoff does exist in the choice between inflation and unemployment in the short-run in the economy. The findings show that the conventional Phillips remains absent even on account of controlling for supply shocks, but clearly emerges as we incorporate the extended part into the basic Phillips curve framework. The results of the extended Phillips curve show that the speed of recovery as captured by the extended part is an important factor in explaining inflation and the strategy for dis-inflation and recovery from adverse supply shocks.

The negative and significant estimate of the coefficient of growth gap indicating the choice of speed of recovery is an important finding of the exercise. With the exception of Dholakia (1990) who initially examined the hypothesis of the extended Phillips curve for India, the questions of alternate adjustment paths and speed of recovery have largely remained unexplored. The present findings though corroborate the earlier conclusion of Dholakia (1990) on the hypothesis of the extended Phillips curve and the strategy for recovery; significantly differ from his findings on the basic inflation-unemployment tradeoff. Our results indicate an upward sloping short-run aggregate supply curve that is responsive to market driven prices. It can be argued that the emergence of the tradeoff has come from the backdrop of the economy moving from inward looking and control oriented regime to the liberalized and trade oriented policies. It indicates that, as the economy becomes more integrated to international trade with markets operating on the demand-supply forces, inflation is no longer driven only by domestic demand factors.

Domestically, in the face of high inflation and prevailing unemployment scenario, a strategy for recovery (growth) from adverse supply shocks has important policy implications. The existing policy concerns in India and other developing countries recognize not only a tradeoff between demand contraction policies to control inflation that can cause the unemployment to rise, but also speculate about the subtle tradeoff in the adjustment path of a fast recovery of the economy leading to high inflation. These concerns have been expressed without any supporting empirical evidence. The findings of our paper suggest that a strategy of fast recovery would be the best way forward for a developing country like India because the subtle tradeoff between the rate of recovery and inflation is negative and not positive. As the essential objective is to achieve growth in the face of under-utilized potential, a strategy of high growth would effectively overcome adverse supply shocks in developing countries where labor markets are largely unorganized, segmented and inefficient and where inflationary expectations are based on past several years of experiences thereby leading to a slow speed of adjustment of expectations.

Notes:

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1. Since the sum of weights used in equation (7) has to be unity by definition, we have: $v + v(1-v) + v(1-v)^2 + v(1-v)^3 ....v(1-v)^r = 1$. As this is a geometric series, it yields, 1 -(1-*v*)$^{r+1}$ = 1 ≈ 0.995. i.e. (1-*v*) = (0.005)$^{1/r+1}$.

2. It may be argued that the condition for the long-run equilibrium should be incorporated as a restriction for estimating the equations. However, we have proceeded with the unrestricted estimation for the following reasons: 1) the well defined hypothesis of β_1= 1 can be directly tested with clarity in interpretation; 2) the F test for the restriction and the t-test for β_1 would be equivalent and not give contradictory results; and 3) the purpose of estimation is to test hypotheses and not generate reliable forecast or prediction.

3. The lower and upper bounds for the DW statistic are computed from the tables given in Savin and White (1977) and Farebrother (1980) for models without the intercept. In both tables 2 and 3, only the first equation shows autocorrelation, in rest of the equations the null hypothesis of no autocorrelation cannot be rejected.

4. Incidentally, even when we consider intercept dummy for the supply shock variables, the results do not change substantially.

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