

## New Keynesian Phillips Curve for Pakistan

AHSAN UL HAQ SATTI, WASIM SHAHID MALIK and GHULAM SAGHIR

### I. INTRODUCTION

Recently macroeconomists have moved to a new neo-classical synthesis by integrating Keynesian features like imperfect competition and nominal rigidities with dynamic stochastic general equilibrium model of the *Real Business Cycle Theory* with micro foundations and rational expectations, [see, for instance, McCallum and Nelson (1999)]. The standard model comprises of a trinity; consumption and inflation adjustment equations with a monetary authority's reaction function. One of the pillar of the model-inflation adjustment equation, also known as New Keynesian Phillips Curve (NKPC) in the literature, has at least two important features; unlike the traditional Phillips curve the NKPC is forward-looking; and it has been derived from the profit maximising behaviour of the firms in a monopolistically competitive market structure.

In this type of framework, instead of starting with the *ad hoc* curves, we investigate the price setting behaviour of firms while formulating the firms' profit maximisation problem. It has an added advantage of analysing the deep structural parameters of the model, e.g. the degree of price inertia, parameter of firms' time preference, etc, which are the important ingredients of policy making. On the other hand in this type of inflation adjustment equation, inflation is determined by expected future inflation, which has certain implications for policy making. For instance, contrary to the case of traditional or backward-looking Phillips curve, policy maker can deflate the economy almost immediately at no cost.

An important issue remains however that whether or not the economic agents are forward-looking. For instance, Furher and Moore (1995) highlights that the economy consists of a combination of forward-looking as well as backward-looking agents, thus showing the importance of previous periods' inflation in determining the current inflation. For this reason most of the studies in the area include hybrid New Keynesian Phillips curve [see for instance, Gali and Gertler (1999)].

The empirical evidence on the subject is mixed. An important issue regarding the NKPC is how to estimate it. The NKPC is estimated either through Generalised Method of Moments (GMM), Maximum Likelihood (ML) technique or the Vector Auto-

Ahsan ul Haq Satti <goodhaq@yahoo.com> is PhD student at the International Islamic University, Islamabad. Wasim Shahid Malik <wmalik11@yahoo.com> is Research Economist at the Pakistan Institute of Development Economics, Islamabad, Ghulam Saghir <saghireconomist@yahoo.com> is PhD student at the Pakistan Institute of Development Economics, Islamabad.

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regression (VAR). Surprisingly evidence based on different techniques is not the same.<sup>2</sup> There are certain merits and demerits of these techniques.<sup>3</sup> For instance, GMM technique is easy to handle and require minimum assumptions about exogenous variables but it gives biased results in small samples and choice of instruments is not an easy task, [Stock, *et al.* (2002)].

Despite importance of NKPC in the literature there is limited evidence on NKPC in developing countries. In case of Pakistan, to our knowledge, this issue has not been investigated yet. On the other hand the issue of disinflationary policy by State Bank of Pakistan since 2005 is much debated issue on media and among academia and researchers in the country. Hence there is a need for estimating NKPC as it possesses different policy implication regarding disinflationary policy.

In this regard the present study focuses on investigating how well the NKPC explains the dynamics of inflation in Pakistan. Following Gali and Gertler (1999), we have estimated standard NKPC for Pakistan over the period 1976–2006 using GMM. We have also estimated hybrid forward- and backward-looking model. Both types of models are estimated as reduced form equations as well as in the form of structural equations.

We have found that future expectations of inflation play significant role in inflation determination. Next we have estimated the inflation adjustment equation both with output gap and real marginal cost as determinant of inflation and find that real marginal cost and not the output gap is driving force of inflation. For the case of hybrid NKPC, results show that the inflation does not possess backward inertia rather it is dominated by forward-looking behaviour. We have also found, with the help of estimating structural NKPC that the degree of price stickiness in Pakistan is very high while the fraction of firms using backward-looking rule in price setting is quite low.

Rest of the study proceeds as follows. Section II reviews the theoretical framework underlying the NKPC in comparison to the traditional Phillips Curve. Section III deals with the empirical methodology. Section IV presents the empirical results both for the standard and hybrid NKPC. Finally Section V concludes the paper.

## II. THEORETICAL FRAMEWORK

Negative slope of Phillips curve could be explained in either setup: Keynesian as well as Monetarists. According to Keynesians nominal wages are fixed for some period, so any increase in money supply and hence in prices would cause real wage to decline, thereby increasing labour demand. Assuming there are unused resources in the economy this increased labour demand by firms would result in higher employment thereby reducing unemployment. But on the other hand wages and prices are perfectly flexible in the classical setup. So any change in money supply would be accompanied by increase in both nominal wages as well as in prices. However workers directly observe wage increase but information regarding price change is available only with a lag. In this way workers face signal extraction problem and they increase labour supply assuming as if their relative price (real wage) has increased.

<sup>2</sup>See for instance, Gali and Gertler (1999), Gali and Gertler and Lep-sid (2001) for GMM; Fanelli (2005) and Tillmann (2005) for VAR; and Jesper Lindé (2001) for MLE, among others. Results based on GMM normally support the NKPC while for ML it is not the case.

<sup>3</sup>See for instance, Fanelli (2005).

Notwithstanding the different interpretation of negative slope of the Phillips curve in the short run both schools of thought agreed on the long run neutrality of money. Both have reached at the same result within the framework of Adaptive expectations. Economic agents are assumed to be backward-looking. Policy-maker takes the position of private agents on expected inflation as given and then decides on the monetary policy shock.<sup>4</sup> So policy is effective in the short run but not in the long run, making long run Phillips curve vertical.<sup>5</sup> An important point here is that agents make systematic forecast errors. It is important to note here that in this setup deflationary policy is much costly in terms of loss in output.

However macroeconomists in the 1950s and 60s were ignoring the basic assumption of Microeconomics, *rationality*. Agents are rational so are their expectations. They utilise all available information to forecast inflation for the next period and forecast error contains information that was not available to workers at the time of forecast. In this way policy-maker cannot systematically change the state of the economy. The idea led to the emergence of *Policy Irrelevance Proposition*, [Sargent and Wallace (1975)]. Fischer (1977), Taylor (1979, 1980) and Calvo (1983) responded to this new challenge to defend the Keynesian's position. Due to overlapping wage contracts and the market power of the firms, policy can have real effect even if the expectations are rational.

Almost a decade ago, some researchers tried to incorporate Keynesian assumptions in the Real Business Models, [see for instance, McCallum and Nelson (1999); Gali and Gertler (1999); Rotemberg and Woodford 2003]. The models are built within the rational expectations framework with complete micro-foundations. Consumers, while maximising their inter-temporal utility, take into account the future stream of income. Firms maximise their profit considering future expected cost of production and facing probability of being unable to change the price in the near future. The small general equilibrium model consists of new forward-looking IS and Phillips Curves and monetary authority is assumed to follow a state-contingent rule.

## Model

Consider monopolistically competitive firms which are unable to adjust their prices each period. Following Calvo (1983) assume that each period a particular firm faces a constant probability  $(1-\lambda)$  of adjusting price. So on the whole  $(1-\lambda)$  of all the firms are able to adjust their prices each period. In this way the parameter  $\lambda$  is the degree of nominal rigidity, [Walsh (2003)]. Hence a larger value of  $\lambda$  implies a larger time expected to adjust the price of a firm. In this case the firm, while setting the price, maximise the current and expected profits keeping in view that in the next  $[1/(1-\lambda)]$  periods it would not be able to adjust the price, [Gali and Gertler (1999)].

<sup>4</sup>Workers, when engaging in wage contracts, have information only on previous period's inflation so they make decisions based on past trend in inflation. On the other hand policy-maker sets policy instrument with complete information on agents' position.

<sup>5</sup>In the Keynesian setup policy is effective for the period of wage contract but in the monetarists' view effect of policy lasts for the time, workers do not have information on their relative price change.

The representative firm set its price to maximise current and future profits

$$\max_{p_t^*} E_t \sum_{i=0}^{\infty} \lambda^i \beta^i \left[ \left( \frac{p_t^*}{P_{t+i}} \right) c_{t+i} - mc_{t+i} c_{t+i} \right] \quad \dots \quad \dots \quad \dots \quad (1)$$

Where  $p_t^*$  is the price set by all firms setting their price in period  $t$ , because by assumption all firms are identical except the product differentiation and their time of setting prices is different. So in case of all firms setting their prices in period  $t$  are identical and set the same price.

By taking first order conditions, solving the model and then linearising around steady state we get the following inflation adjustment equation

$$\pi_t = \beta E_t \pi_{t+1} + k mc_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

Where  $k = \frac{(1-\lambda)(1-\beta\lambda)}{\lambda}$

Equation (2) is the standard New Keynesian Phillips Curve (NKPC), in which current inflation depends on the stream of future expected real marginal cost.<sup>6</sup> Comparing this to traditional Phillips curve we can see the following differences.<sup>7</sup> First, unlike the traditional Phillips curve, NKPC contains future expected inflation. It means any thing which is expected to happen in the future and that will affect future course of inflation would exert pressure on the current inflation.<sup>8</sup> Second NKPC is based on micro foundations with explicit optimising decision of firms. It has an advantage analysing some structural parameters of the economy like  $\lambda$ ; the degree of nominal rigidity and  $\beta$  the discount factor or agents' rate of time preference. Third, disinflationary policy is no more costly according to NKPC. Any announcement by the central bank, if credible, influences the future expectations of private agents thereby changing the current inflation. Fourth, real marginal cost and not the output gap is the factor affecting inflation.

However, under certain assumptions, there is a relationship between real marginal cost and output gap,

$$\phi_t = \eta (y_t - y_t^f) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

Where  $y_t^f$  is the flexible price equilibrium output and  $\eta$  is the output elasticity of real marginal cost, [Gali and Gertler (1999)]. So inside the parentheses is the output gap. With this relationship between real marginal cost and output gap, Equation (2) becomes

$$\pi_t = \beta E_t \pi_{t+1} + k' (y_t - y_t^f) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (4)$$

<sup>6</sup>Iterating equation... forward yields

$$\pi_t = k \sum_{i=0}^{\infty} \beta^i E_t [mc_{t+i}]$$

<sup>7</sup>For details see Walsh (2003), chapter 5.

<sup>8</sup>Expectations are self-satisfied.

Where  $k' = \frac{\eta(1-\lambda)(1-\beta\lambda)}{\lambda}$

As the data show, disinflation is costly as inflation persists. So it is common to augment the standard NKPC with lagged inflation: both future and the past are relevant in determining the current inflation, see for instance, Furher and Moore (1995); Furher (1997); Rudebusch (2002); Gali and Gertler (1999); and Gali, Gertler, and Lopez-Salido (2001).<sup>9</sup> In this case the inflation adjustment equation becomes<sup>10</sup>

$$\pi_t = \beta E_t \pi_{t+1} + k' (y_t - y_t^f) + \theta \pi_{t-1} \quad \dots \quad \dots \quad \dots \quad \dots \quad (5)$$

Here  $\theta$  is the degree of backward-looking behaviour in price setting in the economy. According to this Hybrid NKPC current inflation is determined by output gap (or real marginal cost), previous period's inflation and future expected inflation.

### III. ESTIMATION ISSUES AND METHODOLOGY

Regarding empirics of New Keynesian Phillips Curve there are at least three issues that are worth discussing here. First, NKPC, when estimated in the form of Equation (2) does not capture the dynamics and persistence of inflation showed by data. An important issue in this regard is that NKPC implies negative relationship between inflation and output gap and hence positive relationship between inflation and unemployment [Estrella and Furher (2002)].<sup>11</sup> However in the data the actual relationship between output gap and inflation is positive; see for instance Sbordone (2001) for U.S. In case of Pakistan Malik, But and Tashfeen (2006) shows a negative relationship between inflation and one period lagged unemployment. For the issue in hand we have estimated the relationship between inflation and one period lagged output gap and find the following results<sup>12</sup>

$$\pi_t = \pi_{t-1} + 0.192 (y_{t-1} - y_{t-1}^f) \quad \dots \quad \dots \quad \dots \quad \dots \quad (6)$$

(0.1624)

Furher and Moore (1995) put forward that in the NKPC inflation leads the output gap. But Gali and Gertler (1999) explained that the U.S. data does not support this hypothesis and shows lead of output gap over inflation. In this study we have estimated dynamic correlations between inflation and output gap for Pakistan.<sup>13</sup> Our results show that the current output gap moves positively to future inflation but negatively to lagged inflation rate. So output gap take a lead over inflation in case of Pakistan.

Second, in empirical literature output gap rather than real marginal cost has been used to estimate NKPC. However according to the theory real marginal cost is the driving

<sup>9</sup>Empirical evidence on the importance of the backward-looking behaviour in the price setting, in these studies, is mixed.

<sup>10</sup>Furher (1997) and Rudebusch (2002) include output gap as explanatory variable while Gali and Gertler (1999); and Gali, Gertler and Lopez-Salido (2001) include real marginal cost.

<sup>11</sup>when  $\beta=1$  and equation ... is lagged one period, we obtain

$\pi_t = \pi_{t-1} - k' (y_{t-1} - y_{t-1}^f)$ , [see Gali and Gertler (1999)].

<sup>12</sup>Standard error in parentheses.

<sup>13</sup>Figure 1 in Appendix.

force of inflation. Gali and Gertler (1999) explains that log linear relationship between output gap and real marginal cost could be established only under certain restrictive assumptions, which may not be the case in reality.

Third, Equation (2) cannot be estimated with simple OLS and data on expected inflation are also needed. For that matter some other technique is needed. Regarding the estimation issues the New Keynesian Phillips Curve is estimated by Generalised Method of Moments (GMM) and Maximum Likelihood (ML) techniques. It is note worthy that studies based on different techniques present different results. It means results of estimation of NKPC are sensitive to the choice of estimation technique. In this study, following Gali and Gertler (1999), we have used GMM approach to estimate NKPC. However estimates based on this technique may be biased in small sample and the issue of weak instruments remains there, [Stock, *et al.* (2002)].<sup>14</sup>

Fourth, instead of just estimating reduced form equation, we can estimate structural equation which can help identify deep parameters of the economy.

#### IV. DATA AND ESTIMATION RESULTS

We have used annual data for Pakistan over the period 1976–2006. For real marginal cost log labour income share excluding the share of agriculture is taken.<sup>15</sup> Inflation is calculated as percentage change in GDP deflator. Data on GDP and GDP deflator are taken from International Financial Statistics (IFS) and that on employed labour force and related variables are taken from Labour Force Survey (LFS) and Economic Survey of Pakistan.<sup>16</sup>

We have estimated dynamic correlations between inflation and real marginal cost both at leads and lags finding a positive correlation (Figure 1 in Appendix). It means whenever there is a positive shock to real marginal cost it would lead to higher inflation in the future. In formal econometric analysis, first, we have estimated reduced form equation of NKPC. Using GMM as estimation technique and two periods' lag inflation, labour share, output gap, call money rate, wage inflation and CPI inflation as instruments we find the following result [Equation 7].

$$\pi_t = 0.0453 mc_t + 0.6189 E_t\{\pi_{t+1}\} \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

(0.0217)(0.1599)

The results seem quite supportive for the NKPC in Pakistan. Both parameters (slope coefficient of real marginal cost and discount factor) are positive and statistically significant with magnitude in a reasonable range. It is important to note that the magnitude of coefficient on future expected inflation is quite high in a developing country.<sup>17</sup>

<sup>14</sup>Empirical evidence indicates that GMM estimates are biased towards supporting inflation dynamics implied by NKPC.

<sup>15</sup>With Cobb-Douglas production function  $Y_t = A_t K_t^\alpha N_t^{1-\alpha}$ , marginal cost is given by  $MC_t = S_t / (1 - \alpha)$ , where  $S_t = W_t N_t / P_t Y_t$ .

<sup>16</sup>Data on GDP deflator is corrected for rebasing of GDP in 1999-2000.

<sup>17</sup>It contradicts the supposition that people in developing countries are forward-looking while making economic decisions.

Following Gali and Gertler (1999) we have also estimated the same model with same instruments except for a change that output gap and not the real marginal cost is used as determinant of inflation.

$$\pi_t = -0.1543x_t + 0.9338E_t\{\pi_{t+1}\} \quad \dots \quad \dots \quad \dots \quad \dots \quad (8)$$

(0.0858)(0.0414)

Not surprisingly we find negative and statistically significant coefficient on output gap in inflation adjustment equation, which is clear contradiction to what theory predicts.<sup>18</sup>

Furher (1997) asserts that forward-looking component of inflation becomes redundant once the lagged inflation term are included in estimation process. To test such an issue for the case of Pakistan we have also estimated the Hybrid New Keynesian Phillips Curve.<sup>19</sup> Our results (Equation 9) indicate that the presence of backward-looking terms could not undermine the importance of forward-looking term in the inflation adjustment equation and inflation dynamics are dominated by the movement in expected future inflation. Surprisingly the parameter on lagged inflation (degree of backward-looking behaviour in price setting), though positive, is statistically insignificant. This result again supports the earlier one that future expectations play important role in determining inflation in developing country like Pakistan.

$$\pi_t = 0.0435mc_t + 0.6136E_t(\pi_{t+1}) + 0.0165\pi_{t-1} \quad \dots \quad \dots \quad (9)$$

(0.0239)(0.1638)(0.1083)

Then we move on to estimating structural equation, which helps estimating the structural parameter, the probability that a particular firm could not set its price in the current period—the degree of price stickiness in the economy. Using nonlinear GMM approach we have estimated Equation (2) with both types of orthogonality conditions we find the following results.<sup>20</sup>

$$\pi_t = 0.0498mc_t + 0.5854E_t\{\pi_{t+1}\} \quad \dots \quad \dots \quad \dots \quad \dots \quad (10)$$

(0.1657)

$\lambda = 0.9043$

With the degree of price stickiness (0.0128)

We find the same result for the case of parameters on real marginal cost and expected future inflation as in the case of reduced form evidence. Results of structural estimation show that there is high degree of price stickiness. Our results are robust as we find almost same results with the other orthogonality condition as follows

$$\pi_t = 0.0453mc_t + 0.6188E_t\{\pi_{t+1}\} \quad \dots \quad \dots \quad \dots \quad \dots \quad (11)$$

(0.1599)

<sup>18</sup>Gali and Gertler (1999) highlights the importance of using real marginal cost as opposed to output gap.

<sup>19</sup>See also Rudebusch (2002) for evidence on U.S. data.

<sup>20</sup>For details on orthogonality conditions, see Gali and Gertler (1999).

With the degree of price stickiness  $\lambda = 0.9064$   
(0.0140)

We have also estimated the structural NKPC restricting discount factor equals one. Our results remain robust to even this specification. For detailed results of structural estimation see Appendix. Finally as a test of robustness we have estimated all equations increasing one more lag of all instruments and none of our results changed significantly.

## V. CONCLUSION

In this paper the issue of inflation dynamics in Pakistan based on New Keynesian Phillips Curve has been investigated. Standard NKPC is estimated both in reduced and structural form considering real marginal cost and output gap as driving force of inflation. We have also estimated hybrid model both with expected future inflation and lagged inflation as determinant of current inflation.

It has been found that future inflationary expectations play significant role in inflation determination. Dynamic correlations between inflation and real marginal cost show that inflation co-moves positively with real marginal cost, both at leads and lags. Similarly by comparing results of NKPC with real marginal cost and output gap we find that real marginal cost and not the output gap is driving force of inflation. For the case of hybrid NKPC results show that the inflation does not possess backward inertia rather it is dominated by forward-looking behaviour. We have also found that the degree of price stickiness in Pakistan is very high while the fraction of firms using backward-looking rule in price setting is quite low.

Considering it is the first attempt in this area regarding Pakistan economy, there are certain issues that can be investigated in future. Inflation adjustment equation could be derived based on the assumptions consistent with the Pakistan's economy regarding price setting behaviour, market structure etc. Another point is NKPC represents only supply side and not the whole picture of the economy. So there is a need for building a complete *Dynamic Stochastic General Equilibrium* model based on the assumptions suitable for Pakistan's economy.



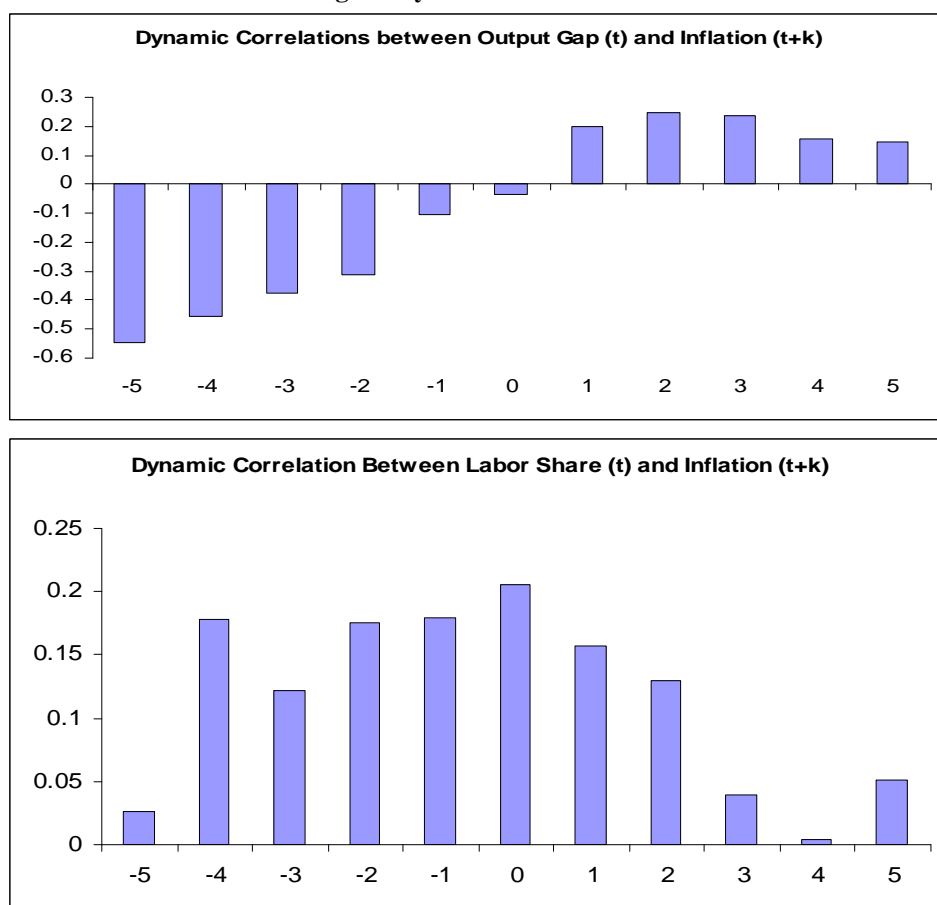
## APPENDIX

Table 1

*Estimation Results of Structural Model*

	$\theta$	$\beta$	$\lambda$
<b>GDP deflator</b>			
(1)	0.904346 (0.012781)	0.585414 (0.165706)	0.049774
(2)	0.906405 (0.013972)	0.61883 (0.159869)	0.04534
<b>Restricted <math>\beta</math></b>			0.005275
(1)	0.929961 (0.038363)	1	
(2)	0.974769 (0.113256)	1	0.000653

Fig. 1. Dynamic Correlations



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