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Introduction

Explaining inflation dynamics is one of the main research areas in macroeconomics. In the New Keynesian literature, inflation is formulated as a function of the level of economic activity and expectations of future inflation. Starting from an assumption of rigid nominal prices, inflation may be derived as a function of the expected future path of firms' real marginal cost.

There is large evidence in the literature that the baseline New Keynesian Phillips Curve (NKPC) model with the labor share proxying real marginal cost as the driving variable of inflation can explain well inflation dynamics in many large countries.

In this dissertation, we estimate the baseline closed economy NKPC model as well as an open economy NKPC model employing the model developed by Leith and Malley (2007).Turkey is a small open economy that is very sensitive to international shocks since in leading industries, most of the Turkish firms extensively use imported raw materials and intermediate goods in their production process. Therefore we decided to employ an open economy extension of NKPC to measure the firms' marginal costs and we chose the Leith and Malley(2007) model due to the fact that it is a general formulation which nests some other models in it as a particular case. The aim of our research is to analyze to what extent the fit of the NKPC to Turkish data improves when we take into account the economy's reliance on intermediate imported inputs.

The rest of the dissertation is organized as follows: In section 1, we present a brief survey of the empirical work on New Keynesian Phillips Curve. In section 2, first, we estimate both benchmark and hybrid NKPC models using inflation expectations data published by Central Bank of Turkey by means of ordinary least squares(OLS)on a monthly basis. Second, we estimate both pure forward looking and hybrid NKPC with quarterly data by means of generalized method of moments(GMM).For quarterly model, we use two alternative data set to check robustness of our results. In each case, both closed economy and open economy specifications are estimated. Finally, we conclude.

1 Literature Review

1.1 Micro foundations of The New Keynesian Phillips Curve

1.1.1 The model

Suppose that the economy consists of a continuum of monopolistically competitive firms indexed by j. Firms adjust their prices a la Calvo(1983)such that in any given period, each firm has a fixed probability θ that it may adjust its price during that period and, hence, a probability 1-θ that it must keep its price unchanged. This probability is independent of the time elapsed since the last provision. Hence the average time over which a price is fixed is given by

$$(1-\theta)\sum k.\theta^{k-1} = \frac{1}{1-\theta}$$

The production is carried out by a representative firm owned by the representative household and household maximizes the following utility function:

$$\max E_o \sum_{t=0}^{\infty} \beta^t \left[U(C_{it}) + V(\frac{M_{it+1}}{P_t}) - Q(N_{it}) \right]$$

st.

$$
\begin{aligned}
\int_0^1 P_{jt}C_{ijt}dj + M_{it+1} + B_{it+1} &= W_tN_{it} + (1+i_t)B_{it} + M_{it} + X_{it} + \Pi_{it} \\
& \quad and \\
Y_{it} &= Z_tN_{it} \\
C_{it} &= \left[\int_0^1 C_{ijt}^{\frac{(\varepsilon-1)}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \\
P_t^* &= \left[\int_0^1 P_{jt}^{1-\varepsilon} dj\right]^{\frac{1}{1-\varepsilon}}
\end{aligned}
$$

Consumers supply labor in a competitive market and so receive labor income W_tN_{it}. They also own the firms producing the individual consumption goods and receive profits Π_{it}.

Individual consumption goods are produced by firms according to a linear production technology.

$$Y_{it} = Z_tN_{it}$$

1.1.2 Household's Problem

The first order conditions for households are

$$C_{ijt} = (\frac{P_{jt}}{P_t^*})^{-\varepsilon} C_{it} \tag{1}$$

$$U'(C_{it}) = \beta E_t \left[(1+r_{t+1})U'(C_{it+1})\right] \tag{2}$$

$$V'(\frac{M_{it+1}}{P_t^*}) = \frac{i_{t+1}}{1+i_{t+1}} U'(C_{it}) \tag{3}$$

$$\frac{W_t}{P_t^*}U'(C_{it}) = Q'(N_{it}) \tag{4}$$

1.1.3 Firm's Problem

Firms that are able to adjust price, choose price optimally maximizing expected discounted profits subject to the demand function and the constraint on the frequency of price adjustment. Firms that do not adjust price, adjust output to meet demand.

The firms maximize the expected present value of real profits they will get at the chosen price P_{jt}, subject to the demand function they face.

$$\begin{aligned} & \max E_t \sum_{k=0}^{\infty} \frac{1}{\Pi_{j=1}^{k}(1+r_{t+j})}(1-\theta)^k \left[\frac{P_{jt}Y_{jt+k}}{P_{t+k}^*} - \frac{W_{t+k}}{P_{t+k}^*}\frac{Y_{jt+k}}{Z_{t+k}}\right] \\ & st \\ Y_{jt} &= (\frac{P_{jt}}{P_t^*})^{-\varepsilon}Y_t \end{aligned}$$

Since all the firms adjusting their prices at period t , charge the same price we can write

$$P_{jt} = P_t$$

where P_t denotes the optimal price of any individual good charged by any firm. Price index is an average of the price charged by the fraction θ of firms setting their prices in period t and the average of the remaining fraction (1-θ) of all firms that set their prices in earlier periods. The average price of nonadjusters, on the other hand, is just the average price that prevailed in period t-1. Therefore using the price aggregation rule $P_t^* = \left[\int_0^1 P_{jt}^{1-\sigma}dj\right]^{\frac{1}{1-\varepsilon}}$ we can write,

$$P_t^* = \left[\theta {P_{t-1}^*}^{1-\varepsilon} + (1-\theta) P_t^{1-\varepsilon}\right]^{1/(1-\varepsilon)} \tag{5}$$

1.1.4 General Equilibrium

Loglinearization of the model, around the steady state gives,

IS :

$$y_t = E_t y_{t+1} - r_{t+1}$$

LM:

$$m_{t+1} - p_t^* = y_t - \frac{1}{i} i_{t+1}$$

Labor Supply:

$$w_t - p_t = \gamma y_t - (\gamma - 1) z_t$$

Price setting

$$p_t = \beta(1-\theta) E_t p_{t+1} + [1 - \beta(1-\theta)] (w_t - z_t)$$

$$p_t^* = (1-\theta)^* p_{t-1} + \theta p_t$$

Production Function:

$$n_t = y_t - z_t$$

The last three equations can be combined to give a Phillips curve relation.

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta} \gamma x_t \text{ where } \mathrm{x}_t = y_t - z_t \tag{6}$$

The optimal price, set at period t by the set of firms adjusting their prices in that period, is the price that maximizes expected discounted profits subject to the process for determining when the firm will next be able to adjust. This can be expressed as

$$p_t = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\left[mc_{t+k}^n\right]$$

Thus firms consider the expected future path of marginal cost in light of the probability that their prices may remain fixed for a number of periods. Combining this with expression for the aggregate price level makes it possible to derive a New Keynesian Phillips Curve:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda mc_t \quad (7)$$

where mc_t is the percent deviation of the firms real marginal costs from its steady state level, $\lambda_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ is a function of the frequency of price adjustment , θ, and discount factor β.

1.2 Inflation Dynamics and the New Keynesian Phillips curve: Empirical Fit

1.2.1 Closed Economy NKPC

Gali and Gertler(1999) develop and estimate a structural model of inflation. Their approach is new in three aspects (1) they use marginal cost as the driving force of the inflation instead of an ad-hoc output gap. (2)They allow a fraction of firms use a backward looking rule to set prices to account for the inflation persistence suggested by the data.(3) They identify and estimate all the structural parameters of the model using conventional econometric methods.

Using U.S. data, Gali and Gertler (1999) estimate the following structural Phillips Curve where all the coefficients are explicit functions of the three model parameters:θ, which measures the degree of price stickiness; ω,the degree of "backwardness" in price setting, and the discount factor β, using non-linear instrumental variables estimator applied to Equation 8 given coefficient equations.

$$\pi_t = \gamma_f E_t \pi_{t+1} + + \gamma_b \pi_{t-1} + \lambda \psi_t \quad (8)$$

$$where$$

$$\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\theta + \omega(1-\theta(1-\beta))} \quad (9)$$

$$\gamma_f = \frac{\beta\theta}{\theta + \omega(1-\theta(1-\beta))} \quad (10)$$

$$\gamma_b = \frac{\omega}{\theta + \omega(1-\theta(1-\beta))} \quad (11)$$

Gali and Gertler (1999) propose using average unit labor cost to measure nominal marginal cost, which means using labor share of income as a proxy for real marginal cost given a Cobb-Douglas production technology.

Gali and Gertler's (1999) main results are the following: (1) The labor share is a statistically significant driving variable of the inflation dynamics. (2)Backwardness is statistically significant, but quantitatively unimportant. Hence, forward looking behavior dominates price setting. Thus Gali and Gertler (1999) conclude that the NPKC provides a good first approximation to the dynamics of inflation in U.S..

More recently, Gali, Gertler and Lopez-Salido (2001) provide evidence on the hybrid NKPC for the Euro area and use the results to compare the characteristics of European inflation dynamics with those observed in the U.S.. They extend Gali,Gertler (1999) by allowing for increasing marginal costs.

The following equation is the baseline relation for inflation that they estimate.

$$\widehat{\pi}_t = \beta E_t \widehat{\pi_{t+1}} + +\lambda \widehat{mc}_t \tag{12}$$

$$where$$

$$\lambda = \frac{(1-\alpha)(1-\theta)(1-\beta\theta)}{\theta(1+\alpha(\varepsilon-1))} \tag{13}$$

They also estimate a hybrid version of the NKPC:

$$\pi_t = \gamma_f E_t \pi_{t+1} + +\gamma_b \pi_{t-1} + \lambda \widehat{mc_t} \tag{14}$$

$$where$$

$$\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta(1+\alpha(\varepsilon-1))} \tag{15}$$

$$\gamma_f = \frac{\beta\theta}{\theta+\omega(1-\theta(1-\beta))} \tag{16}$$

$$\gamma_b = \frac{\omega}{\theta+\omega(1-\theta(1-\beta))} \tag{17}$$

where θ stands for degree of price rigidity, α stands for curvature of the production function and ε stands for elasticity of demand. The larger the α and ε , the more sensitive is the marginal cost of an individual firm to deviations from of its price form the average price level: everything else equal, a smaller adjustment in price is desirable in order to offset expected movements in average marginal cost.

As a result,they find that the hybrid NPKC fits the Euro area data very well and inflation dynamics in the Euro area appear to have a stronger forward-looking component than in the U.S.

Yazgan and Yılmazkuday (2005) estimate both the benchmark and the hybrid versions of the NKPC following the approach in Gali and Gertler (1999) using Turkish data. They find empirical support for the benchmark NPKC in contrast to previous applied literature. Moreover, the hybrid NKPC is refuted by the data, i.e. the backward-looking behavior is found to be statistically insignificant.

They conclude that there is significant empirical evidence that NKPC provides a reasonable description of inflation for Turkey.They find that prices are much more flexible in Turkey than in the U.S. and that Turkish inflation is more sensitive to movements in real marginal cost than U.S. inflation. They propose a possible explanation based on the structural characteristics of the Turkish economy for this: " First of all, Turkey is a small open economy that is more sensitive to international shocks such as changes in terms of trade. Secondly and perhaps more importantly, another significant portion of their costs results from state produced inputs (such as energy, some raw materials etc.) whose prices experienced large increases during the estimation period because of a considerably high public sector deficit. Another consequence of this high public sector deficit is the exceptionally high interest rates which contribute to the operating costs of the firms. These factors may have caused the Turkish inflation rate to be more sensitive to movements in marginal costs, since it seems reasonable to think for the firms that, when quick changes in important inputs is highly probable, the cost of keeping prices fixed is much more severe than in the U.S. and some Euro area countries."(Yazgan and YIlmazkuday (2005))

1.2.2 Open Economy NKPC

In recent years, much research has been devoted to the integration of open economy components into New Keynesian Modelling framework and particularly into New Keynesian Phillips Curve specification.

Gali and Lopez-Salido (2001) estimate an open economy NKPC for Spain of which specification differed from the closed economy case in incorporating imported intermediate goods into production function. They state that "movements in the exchange rate can fuel domestic inflation behavior through import prices....Once we depart from the assumption of constant elasticity of output with respect to labor, income share may no longer be a suitable indicator of real marginal costs when other non-labour inputs are used. In particular if some of the intermediate goods are imported, information about their relative price (which is influenced by exchange rate) may be needed to measure the firms' marginal costs"(Gali and Lopez-Salido (2001) pp185).

By GMM they estimate the following reduced-form equation:

$$\pi_t = E_t \pi_{t+1} + \lambda_1 s_t + \lambda_2 (p_{M,t} - \omega_t)$$

where parameters λ_1 and λ_2 are functions of the structural parameters. s_t stands for labor share,$p_{M,t}$ stands for import prices and ω_t stands for nominal wage. They found that the estimated sign of relative import price coefficient is positive and highly significant and they concluded that the Spanish disinflation of the past two decades can be partly accounted for by the decrease in the relative price of imported inputs. Also the coefficients on expected inflation and real unit labor costs are found to be significant as suggested by theory.

Genberg and Pauwels (2000,2005) propose a weighted average marginal cost featuring intermediate imported input costs as well as labor input costs to account for the open economy influences on inflation. In their paper, they apply the theoretical developments of Gali and Gertler (1999) to the small economy of Hong Kong by extending the model incorporating open economy considerations and carry out estimation using GMM.

In construction of the model, they employ a Cobb-Douglas production technology which consists of two inputs: augmented labor (AL) and import component (M)The cost minimization yields the following shadow price in real terms:

$$\lambda_t = \frac{w_t L_t}{\alpha Y_t} = \frac{p^{im} M_t}{(1-\alpha)Y_t}$$

where w_t is nominal wage and p^{im} is intermediate import price. As a weighted average marginal cost measure, they define the following "log deviation from mean open economy index $(\widehat{omc})$:

$$\begin{aligned}
\widehat{omc} &= \zeta \hat{s_t^L} + (1-\zeta)\hat{s_t^{im}} \\
& \quad where \\
\hat{s_t^L} &= \ln(\frac{w_t L_t}{Y_t P_t}) \\
\hat{s_t^{im}} &= \ln(\frac{p^{im} M_t}{Y_t P_t})
\end{aligned}$$

Thus, final expression for the rate of inflation is:

$$\pi_t = \omega^f E_t \pi_{t+1} + \omega^b \pi_{t-1} + \delta^h \widehat{omc} + \varepsilon \tag{18}$$

In their estimation they assume that ζ is 0.5 implying that labor costs and intermediate import costs has equal weight in production costs.

Genberg and Pauwell's (2005) approach yields four main results: (1)marginal cost version of the New Keynesian Phillips Curve gives results that are consistent with theory only if the imported prices get a substantial weight (typically larger than one half) in the measure of marginal cost."(2)forward looking behavior is important for inflation dynamics in Hong Kong (3)Output gap also performs well in the inflation Equation 18.The results are sensitive to the exact choice of instruments used in GMM estimation and also sensitive to the sample specification.

Batini, Jackson and Nickell (2005) extend the baseline model by allowing variations in equilibrium price markup due to external competitive pressures, by incorporating labor adjustment costs in line with Rotemberg(1982) and Layard et al (1991). They also account for the cost impact of changes in material input prices when production function takes a general form. They estimate the following open economy Phillips curve for the UK (in levels, they also estimate it using first differences) using GMM.

$$\begin{aligned} \pi_t &= \alpha_o + \phi E_{t-1}\pi_{t+1} + \alpha_1 E_{t-1} z_{p,t} + \alpha_{11} E_{t-1}(y_t - y_t^*) + \alpha_{12} E_{t-1}(p_t^w - p_t^*) \\ &\quad + \alpha_1 E_{t-1} s_{L,t} + \alpha_{13} E_{t-1}(p_{m,t} - p_t) - \alpha_2 \phi E_{t-1} \Delta n_{t+1} + \alpha_2 \phi E_{t-1} \Delta n_t + v_t \end{aligned}$$

where ϕ is a discount factor, p_t^* is the log of optimal price in the absence of dynamic adjustment costs and Δn_t denotes the change in the (log) employment rate, $z_{p,t}$ represents long-term secular shifts arising from e.g. from changes in the rigor of antitrust regulation. $(p_t^w - p_t)$ is a measure of weakness or strength of foreign competition, where p_t^w is the world price of domestic GDP in domestic currency terms, and $(y_t - y_t^*)$ represents output gap, $s_{L,t}$ represents labor share and $(p_{m,t} - p_t)$ represents terms of trade.

Batini, Jackson and Nickell (2005) conclude that these extensions to the hybrid Philips Curve of Gali and Gertler (1999) and Sbordone(2002) are crucial for the fit of Philips Curve to UK data. Second they find that inflation is highly forward looking with a coefficient on expected inflation equal to 0.69. Third, the labor share term is strongly significant and the additional cost elements (real import prices and the change in oil prices) are also important. Fourth, the employment adjustment costs are also very relevant for price setting and for inflation in general. Fifth, external competitive pressures also seem to affect UK inflation via their impact on the equilibrium price markup of domestic firms. Finally, they do not get significant values for the variables that are supposed to capture the variations in the price markup equilibrium value.

The paper stresses two additional points that are both theoretically and empirically relevant. First, marginal cost will be inaccurately measured by the labor share if there are employment adjustment costs. Second, the form of marginal cost will have to be adjusted if the production function is not Cobb-Douglas in order to take into account of the relative price of imported materials when these are used in production.

Leith and Malley (2007) introduces open economy factors into NKPC model by taking into account open economy terms of trade effects in determination of output inflation. They construct a model of firms' price setting behavior which allows firms to sell their product in both home and foreign markets and to substitute imported intermediate goods for domestic labor in production. So two channels through which terms of trade effects may influence the firm's price setting decisions via their impact on marginal costs is captured. Firstly, changes in demand for domestic products relative to those produced abroad and secondly changes in the prices of imported intermediate goods relative to other inputs in production process is allowed. Leith and Malley (2002,2007) specification gives rise to a NKPC model which nests existing closed and open economy models.[1]

In their specification, the demand for the firms' product depends on its price relative to the prices of other domestic producers, as well as the amount of domestic and foreign, public and private consumption and intermediate good demand allocated to domestically produced goods.

$$y(z)_t = (\frac{p(z)_t}{p_t^d})^{-\theta}(c_t^d + g_t^d + m_t^{f*} + c_t^{f*} + g_t^{f*})$$

where m_t^{f*} is the average demand for home country produced goods for use in foreign firms' production. The demand for the firm's product depends upon its price relative to the prices of other domestic producers,as well as the amount of domestic and foreign, public

[1] See for example Sbordone(2002), Gali et al (2000 2001), Gali and Salido-Lopez (2001) and Balakrishnan and Salido-Lopez (2001)

and private consumption and intermediate good demand allocated to domestically produced goods where these proportions depend on the relative prices . Therefore,substitution in demand between goods produced at home and abroad is allowed in describing the demand for the representative domestic firm's product.

The second channel through which terms of trade affects firms' pricing decision is the production function since firms use imported intermediate goods as a factor of production.

$$y(z)_t = (\alpha_n N(z)_t^{\frac{\rho-1}{\rho}} + \alpha_m (m(z)_t^f)^{\frac{\rho-1}{\rho}})^{\frac{\rho-1}{\rho}/\psi} \bar{K}^{1-\frac{1}{\psi}}$$

where $N(z)_t$ and $m(z)_t$ are the labour input and imported intermediate goods used in production. They model these inputs as imperfect substitutes and ρ measures the elasticity of substitution between them. Firms also possess a stock of capital, K, which is assumed, for simplicity, to be fixed and (1 - $\frac{1}{\psi}$) describes the weight given to capital in production.

To take into account the link between the open economy definition of marginal cost and the labor share proxy , the NKPC is reformulated as the following[2]:

$$\begin{aligned} \pi_t &= \frac{\beta\theta}{\lambda} E_t \pi_{t+1} + \frac{\omega}{\lambda} \pi_{t-1} \qquad (19) \\ &+ \frac{(1-\omega)(1-\theta)(1-\theta\beta)}{(1+(\Psi-1)\theta\lambda)} \left[\begin{array}{c} \hat{s}_t^L - (\psi - 1)(\frac{i^s}{1+(1-\Psi)i^s})\hat{y}_t \\ -\left[(1-\rho)(\frac{i^s}{i^s+\bar{s}}) + \rho(\frac{i^s}{1+(1-\Psi)i^s})(\frac{\bar{s}}{\bar{s}+i^s})\right] \\ *(\hat{W}_t - \hat{p}_t^f) + (\frac{i^s}{1+(1-\Psi)i^s})(\hat{p}_t^d - \hat{p}_t^f) \end{array} \right] \\ where\ \lambda &= \omega + \theta\beta\omega + \theta - \omega\theta \end{aligned}$$

where $\hat{s}_t^L$ is the steady state deviation of (log of) labor share, i^s is steady state import share, $\bar{s}$ is steady state labor share, $\hat{y}_t$ is outputgap, $(\hat{W}_t - \hat{p}_t^f)$ is steady state deviation of price of labor relative to import prices and $(\hat{p}_t^d - \hat{p}_t^f)$ is steady state deviation of terms of

[2]See Appendix I at the end of the Leith, Malley (2007) paper for the derivation.

trade.

Leith and Malley (2002,2007) yields three main conclusions: First, the degree of inertia is significant in each G7 economy , moreover UK, US and Canada enjoy less inertia than other European members of G7 and Japan. Second, majority of firms set their prices optimally , in a forward looking manner, rather than following rules of thumb. Moreover, in countries where firms charge prices relatively frequently, the proportion of backward looking firms increases. Finally, there are significant asymmetries in the degree of price stickiness among EMU member states as well as asymmetries in the degree of backward looking price setting.

Rumler(2007) extends baseline model in order to account for open economy effects as well as effects of intermediate goods in the production technology of the firm. Real marginal cost as the driving force of inflation is decomposed into three factors of production: real unit labor cost and prices of imported and domestically produced intermediate goods. In the previous papers on open economy NKPC, (e.g. Leith and Malley(2007), Batini et al. (2005), only imported intermediate goods are used as a factor of production.)

Rumler's (2007) model follows baseline model of Gali and Gertler(1999) and the hybrid specification of NKPC of Gali et al(2001). Particularly, it extends the open economy NKPC model of Leith and Malley(2007) by introducing a third factor of production in order to allow firms to shift between domestic and foreign inputs in production. In his model, international trade takes place at two levels of production. Monopolistically competitive firms sell their products to consumers at home and abroad as well as to domestic and foreign firms for their use as intermediate input.

Rumler(2007) estimates an open economy NKPC of the form employing GMM:

$$\hat{\pi}_t^d = E_t \frac{\theta\beta}{\Delta}\hat{\pi}_{t+1}^d + \frac{\omega}{\Delta}\hat{\pi}_{t-1}^d + \frac{(1-\theta)(1-\omega)(1-\theta\beta)}{(\varepsilon(\phi-1)+1)\Delta}\left[M\hat{C}_t + \hat{P}_t - \hat{p}_t^d + (\phi-1)\tilde{\hat{y}}_t\right] \qquad (20)$$

where $\hat{\pi}_t^d = \hat{p}_t^d - \hat{p}_{t-1}^d$ and $\Delta = \theta + \omega(1 - \theta(1 - \beta))$ and $\beta = \frac{1}{\bar{r}}$ is the steady state discount rate of future profits. Hatted variables denote deviations from steady state and barred variables represents steady state values.

In order to transform the open economy NKPC in Equation 20 into a form appropriate for estimation, Rumler(2007) decomposes marginal cost term that is not firm specific in terms of prices of all factors of production. (in log-linearized form):

$$M\hat{C}_t = \frac{\frac{\bar{w}}{\bar{p}}\hat{w}_t + \frac{\bar{p}^d}{\bar{p}}(\frac{\bar{w}}{\bar{p}^d}\frac{\alpha_d}{\alpha_N})^\rho \hat{P}_t^d + \frac{\bar{p}^f}{\bar{p}}(\frac{\bar{w}}{\bar{p}^f}\frac{\alpha_f}{\alpha_N})^\rho \hat{P}_t^f}{\frac{\bar{w}}{\bar{p}} + \frac{\bar{p}^d}{\bar{p}}(\frac{\bar{w}}{\bar{p}^d}\frac{\alpha_d}{\alpha_N})^\rho + \frac{\bar{p}^f}{\bar{p}}(\frac{\bar{w}}{\bar{p}^f}\frac{\alpha_f}{\alpha_N})^\rho}$$

Plugging this expression into 20 the term in square brackets in 20 can be expressed in terms of relative prices of the factors of production and the labor share:

$$\begin{aligned}[..] \quad = \quad & \hat{s}_{nt} - (\phi - 1)\frac{\bar{s}_{m^d} + \bar{s}_{m^f}}{1 + (1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\hat{y}_t + \frac{\bar{s}_{m^f}}{1 + (1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}(\hat{p}_t^d - \hat{p}_t^f) \\ & - \left[(1-\rho)\frac{\bar{s}_{m^d}}{\bar{s}_{m^d} + \bar{s}_{m^f} + \bar{s}_n} + \rho\frac{\bar{s}_{m^d}}{1 + (1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\frac{\bar{s}_n}{\bar{s}_{m^d} + \bar{s}_{m^f} + \bar{s}_n}\right](\hat{w}_t - \hat{P}_t^d) \\ & - \left[(1-\rho)\frac{\bar{s}_{m^f}}{\bar{s}_{m^d} + \bar{s}_{m^f} + \bar{s}_n} + \rho\frac{\bar{s}_{m^f}}{1 + (1-\phi)(\bar{s}_{m^d} + \bar{s}_{m^f})}\frac{\bar{s}_n}{\bar{s}_{m^d} + \bar{s}_{m^f} + \bar{s}_n}\right](\hat{w}_t - \hat{P}_t^f)\end{aligned}$$

where $\mathrm{s}_n = \frac{wN}{p^d y}$, $\mathrm{s}_{m^d} = \frac{p^d m^d}{p^d y}$, $\mathrm{s}_{m^f} = \frac{p^f m^f}{p^d y}$ are the shares of labor, domestic intermediate goods and imported in GDP, respectively.

$\phi = \frac{(\varepsilon-1)(1+\bar{s}_{m^d}+\bar{s}_{m^f})}{\varepsilon(\bar{s}_{m^d}+\bar{s}_{m^f}+\bar{s}_n)}$ can be derived from steady state markup and the steady state labor and intermediate good shares in production.

Rumler(2007) estimates his model for nine euro area countries and the euro area aggregate to show that this new version of NKPC including three factors of production improves fit considerably compared to the closed economy model. He compares hybrid marginal cost based NKPC in three different settings:(1) a closed economy case (2) an open economy case with only imported intermediate inputs and (3) an open economy case with both imported and domestically produced intermediate inputs. His results show that open-economy aspects are of vital importance for the performance and the fit of the NKPC. Rumler(2007) finds that the price rigidity is systematically higher for the closed economy case than in open economy specification where there are only imported inputs, as in Batini, Jackson and Nickell(2005). Rumler (2007) states that this may be due to the fact that when firms face more variable input costs as they import from volatile international markets they tend to adjust their prices more frequently.

2 Estimates Of NKPC for Turkey

We first estimate the model on monthly data using real inflation expectations data published by Turkish Central Bank by means of ordinary least squares(OLS). Second, estimation is carried out on quarterly data using generalized method of moments (GMM). Four specifications are considered:(1)General closed economy NKPC specification (2)Baseline closed economy Gali and Gertler (1999) Hybrid NKPC specification. (3)Pure forward looking Open Economy NKPC specification (4)Open economy Leith, Malley (2002,2007) hybrid specification. In all specifications both reduced form coefficients and structural coefficients are estimated.

2.1 Analysis with actual inflation expectations data

The following Leith, Malley(2002,2007) Open economy NKPC forms the basis of our estimation:

$$
\begin{aligned}
\pi_t &= \frac{\beta\theta}{\lambda}E_t\pi_{t+1} + \frac{\omega}{\lambda}\pi_{t-1} \\
&+ \frac{(1-\omega)(1-\theta)(1-\theta\beta)}{(1+(\Psi-1)\theta\lambda)} \\
&\left[\begin{array}{c} \hat{s}_t^L - (\psi-1)(\frac{i^s}{1+(1-\Psi)i^s})\hat{y}_t - \\ \left[(1-\rho)(\frac{i^s}{i^s+\bar{s}}) + \rho(\frac{i^s}{1+(1-\Psi)i^s})(\frac{\bar{s}}{\bar{s}+i^s})\right](\hat{W}_t - \hat{p}_t^f) \\ +(\frac{i^s}{1+(1-\Psi)i^s})(\hat{p}_t^d - \hat{p}_t^f) \end{array}\right] \\
where\ \lambda &= \omega + \theta\beta\omega + \theta - \omega\theta
\end{aligned} \tag{21}
$$

where $\hat{s}_t^L$ is the steady state deviation of (log of) labor share, i^s is steady state import share, $\bar{s}$ is steady state labor share, $\hat{y}_t$ is outputgap, $(\hat{W}_t - \hat{p}_t^f)$ is steady state deviation of price of labor relative to import prices,and $(\hat{p}_t^d - \hat{p}_t^f)$ is steady state deviation of terms of trade.

In this section, we estimate both reduced form and structural parameters of the model in Equation 21 for Turkey. Reduced form parameters include fraction of forward looking firms, γ_f , fraction of backward looking firms, γ_b and the dependence of inflation to marginal cost variable, λ. Structural parameters include the firms' steady-state discount factor, β, the probability that a firm can reset their price in period t, θ, and the proportion of firms following rule of thumb pricing behavior in time t, ω. For comparison, we also estimate benchmark closed economy NKPC, and Gali, Gertler(1999) hybrid closed economy NKPC where unit labor costs are used as a proxy for marginal cost.

We use monthly data for Turkey over the period 2001M8-2007M6. For constructing marginal cost, we use unit labor cost derived from OECD Hourly Earnings index (W) , Index of Working Hours in Manufacturing Industry (N)[1], Industrial Production Index (Y) and the consumer price index (P) ; Unit labor cost (ULC) is defined as log(W*N/P*Y) and

[1]Due to unavailability of monthly data, we converted from quarterly data.

Unit import cost (UIC) is defined as log(Pim*M/P*Y) and their steady state deviation are calculated using HP filter. Inflation is measured as logarithmic difference of consumer price index(CPI).[2]

Before estimating Equation 21 for Turkey, it is necessary to obtain data for the steady-state ratio of imported goods used in production relative to GDP, $\bar{p}^f \bar{m}^f / \bar{p}^d \bar{y}$, and the steady-state labour share $\bar{s}$ to construct marginal cost. To account for the possible change in the steady-state ratio of imported goods used in production relative to GDP, we use HP filtered trend of UIC and ULC respectively rather than averages across the sample. This has the desired effect of appropriately capturing the changing importance of imported goods in production over time. For consistency, we also use HP filtered trends in calibrating Ψ to calculate the weights on the open economy terms in our NKPC. To obtain the latter, we followed the approach used in Leith, Malley(2002,2007) and we calculated Ψ as the following:

$$\psi = \frac{a}{\alpha - 1} / (\frac{\bar{s} + i^s}{1 + i^s}) \tag{22}$$

To calculate Ψ and when estimating Equation 21 we assume α to be 11 which implies a mark-up over marginal costs, $\mu = \frac{\alpha}{1-\alpha} = 10\%$ as in Leith, Malley(2002,2007).Then to check robustness of our results , we also consider the case where markup is 40%

Seasonality issue is handled with commonly used program Census X12. Deviations from steady states are calculated by Hodrick-Prescott (HP) filter for all variables.

Since OLS estimation requires that underlying variables of the model and instruments used in estimation are stationary, we test all of the variables for a unit root in their data generation process. We use conventional Augmented Dickey Fuller Tests (ADF) by including a constant term only, and a linear trend together with a constant term in ADF equations.[3]

[2] See Table 1 for a detailed description of the data set.

[3] We used Akaike Info Criterion to choose lag length.

We find no evidence, based on these tests, for a unit root in the variables in question.[4]

2.1.1 Reduced Form Estimation

We present estimation results at Table 3. We first estimate baseline model taking unit labor costs as a proxy for marginal costs. M1 refers to baseline pure forward looking and M2 refers to Hybrid Gali, Gertler(1999) closed economy NKPC model. In both cases, we find expected inflation to be statistically and quantitatively significant, nevertheless unit labor costs are statistically insignificant and are also wrong in sign. In hybrid version, the coefficient of backward looking inflation is also found to be insignificant. Subsequently, we estimate open economy Leith, Malley (2002,2007) NKPC. At Table 3, M3 refers to pure forward looking and M4 refers to hybrid open economy NKPC respectively. Expected inflation is again statistically and quantitatively significant, nevertheless open economy marginal cost derived as in Leith,Malley(2002,2007) is statistically insignificant and is also wrong in sign. The coefficient of backward looking inflation is significant at the 10% significance level and its coefficient is smaller than that of expected inflation. At Table 3, column five presents White Heteroskedasticity Test statistic and associated p-value. In all cases, we did not found any evidence of existing Heteroskedasticity.

Second, we estimate both baseline and open economy versions of NKPC using one lag of marginal cost variables. We find that lagged unit labor cost as well as lagged open economy marginal cost as a driving force of inflation is statistically and economically significant. We present our results at Table 4a. M1, M2 refers to pure forward looking and Hybrid closed economy NKPC whereas M3, M4 refers to pure forward looking and Hybrid open economy NKPC, respectively. In all cases, the coefficient on forward looking inflation is found to be significant. The coefficient on backward looking inflation is found to be significant and is less

[4] See Table 2 for test results.

than that of forward looking inflation. Hence, we conclude that in this specification, inflation is found to be highly forward looking.

The estimated closed and open economy benchmark inflation equation for Turkey are the following:

$$\pi_t = \underset{(0.049)}{0.84} E_t \pi_{t+1} + \underset{(1.53)}{3.01} \hat{u}lc_{t-1}$$

$$\begin{aligned} \pi_t &= 0.82 E_t \pi_{t+1} + 0.001 o\hat{m}c_{t-1} \\ & \quad (0.059) \qquad (0.005) \end{aligned}$$

The estimated closed and open economy Hybrid inflation equation for Turkey are the following:

$$\begin{aligned} \pi_t &= 0.55 E_t \pi_{t+1} + 0.34 \pi_{t-1} + 4.26 \hat{u}lc_{t-1} \\ & \quad (0.139) \qquad (0.153) \qquad (0.0095) \end{aligned}$$

$$\begin{aligned} \pi_t &= 0.61 E_t \pi_{t+1} + 0.23 \pi_{t-1} + 0.011 o\hat{m}c_{t-1} \\ & \quad (0.127) \qquad (0.132) \qquad (0.005) \end{aligned}$$

For open economy NKPC we detected presence of Heteroskedasticity, therefore we used White Heteroskedasticity consistence standard errors for valid inference.

The difference in the coefficients of unit labor cost (ulc)and open economy marginal cost (omc) may be attributed to the relative magnitude of these two variables. For comparison purposes we have indexed the data for unit labor costs. We present the results at Table 4b. The estimated equations are the following:

$$\pi_t = \underset{(0.049)}{0.86} E_t \pi_{t+1} + \underset{(0.049\ )}{0.008} \hat{u}lc_{t-1}$$

$$\begin{aligned} \pi_t &= 0.55 E_t \pi_{t+1} + 0.36 \pi_{t-1} + 0.012 \hat{u}lc_{t-1} \\ & \quad (0.14) \qquad (0.004) \qquad (0.15) \end{aligned}$$

When we use lagged unit labor costs as a proxy for marginal cost, both forward looking and hybrid NKPC fits the data well. On the other hand, since backward looking term is found to be significant, we conclude that hybrid NKPC is a better description of Turkish inflation. Moreover introducing backward looking component increased the slope of marginal cost implying that inflation is more sensitive to changes in unit labor costs. The fraction of forward looking firms are estimated to be greater than that of forward looking firms.

On the other hand, when we use open economy marginal cost as a proxy, we find very similar results to the closed economy case. The coefficients on forward looking and backward looking inflation is reasonably similar, as well as the coefficient on open economy marginal cost and that of unit labor costs

Third, we estimated NKPC using ad-hoc oil inflation variable to take into account its affect on inflation through production costs.. We present the results at Table 5. Oil inflation is found to be statistically significant and economically plausible in pure forward looking setting. Expected inflation is again found to be significant and at the hybrid case its coefficient is again greater than that of backward looking inflation.

Estimated equations are the following:

$$\pi_t = 0.85 E_t \pi_{t+1} + 3.33 \hat{u}lc_{t-1} + 2.39 oil \inf$$
$$(0.047) \quad (1.50) \quad (1.22)$$

$$\pi_t = 0.58 E_t \pi_{t+1} + 0.32 \pi_{t-1} + 4.45 \hat{u}lc_{t-1} + 2.05 oil \inf$$
$$(0.138) \quad (0.151) \quad (1.55) \quad (1.197)$$

Fourth, we estimated a restricted version of NKPC such that the coefficient on forward looking and backward looking inflation sum to one.($\gamma_f + \gamma_b = 1$). Table 6 presents the estimation results. The results are very similar to the previous cases; contemporaneous unit labor cost and open economy marginal cost is found to be insignificant whereas their lagged values are significant.

Subsequently, for robustness check, we consider three other cases: Firstly, we estimate OMC based NKPC for a higher markup of 40%($\mu = 1.4$). Table 7 presents the results. On the other hand it causes the coefficient on marginal cost to decrease. Second, we consider Cobb-Douglas production technology case where elasticity of substitution between labor and intermediate imported goods (ρ) is equal to 1. Hence, we estimate the following equation:

$$\pi_t = \frac{\beta\theta}{\lambda}E_t\pi_{t+1} + \frac{\omega}{\lambda}\pi_{t-1} \quad (23)$$

$$+\frac{(1-\omega)(1-\theta)(1-\theta\beta)}{(1+(\Psi-1)\theta\lambda)} \quad (24)$$

$$\begin{bmatrix} \hat{s}_t^L - (\psi-1)(\frac{i^s}{1+(1-\Psi)i^s})\hat{y}_t - \\ (\frac{i^s}{1+(1-\Psi)i^s})(\frac{\bar{s}}{\bar{s}+i^s})(\hat{W}_t - \hat{p}_t^f) \\ +(\frac{i^s}{1+(1-\Psi)i^s})(\hat{p}_t^d - \hat{p}_t^f) \end{bmatrix} \quad (25)$$

$$where\ \lambda = \omega + \theta\beta\omega + \theta - \omega\theta \quad (26)$$

The variables are defined as before.

We present the results with a markup of 10% and 40% at Table 8 and Table 9 respectively. In either case, higher markup do not affect the coefficients on backward looking and forward looking inflation. However it causes the coefficient on marginal cost to fall considerably. Changing elasticity of substitution between labor and intermediate imported goods did not cause any significant change for any coefficient.

Finally, we estimated output gap based NKPC. Both pure forward looking and hybrid version are refuted by the data. We present the results at Table 10.

2.1.2 Structural Parameters Estimation

We next estimate the structural parameters:fraction of backward looking firms,ω; degree of price rigidity, θ; and the subjective discount factor,β. To minimize nonlinearities we estimate following structural equations for baseline closed economy NKPC and closed economy hybrid NKPC respectively.

$$\theta\pi_t = \theta\beta\pi_{t+1} - (1-\theta)(1-\beta\theta)\hat{m}c_t \quad (27)$$

$$\phi\pi_t = \theta\beta\pi_{t+1} - (1-\theta)(1-\beta\theta)(1-\omega)\hat{m}c_t \tag{28}$$

where $\phi = \omega + \beta\omega\theta + \theta - \omega\theta$

We present the results at first and second columns of Table 11. In pure forward looking specification subjective discount factor β is estimated to be 0.84 where as the degree of price rigidity parameter is estimated to be 0.99 and both are highly significant. On the other hand, in the hybrid specification although backward looking component is found to be statistically different from zero, it is wrong in sign. Therefore, we conclude that hybrid NKPC is refuted by the data when we use unit labor costs as a proxy for marginal cost.

Subsequently we estimate open economy baseline NKPC and hybrid NKPC using the following specifications:

$$\theta\pi_t = \theta\beta\pi_{t+1} - (1-\theta)(1-\beta\theta)(1+\alpha(\Psi-1))^{-1}\hat{m}c_t \tag{29}$$

$$\phi\pi_t = \theta\beta\pi_{t+1} - (1-\theta)(1-\beta\theta)(1-\omega)(1+\alpha(\Psi-1))^{-1}\hat{m}c_t \tag{30}$$

where $\phi = \omega + \beta\omega\theta + \theta - \omega\theta, \psi = \frac{a}{\alpha-1}/(\frac{\bar{s}+i^s}{1+i^s})$. We assumed α to be 11which implies a markup of 10% .We present the results at third and fourth rows of Table 11. In pure forward looking specification subjective discount factor β is estimated to be 0.86 whereas degree of price rigidity parameter is estimated to be 0.99 and both are highly significant. On the other hand, in the hybrid specification although backward looking component is found to be statistically different from zero, it is wrong in sign. Therefore, we conclude that open economy hybrid NKPC a la Leith, Malley(2002,2007) is refuted by the data.

Hence, based on our estimations with monthly data, we conclude that: (1)Forward looking behavior dominates inflation. (2)Lagged unit labor cost as well as lagged open economy marginal cost are significant determinants of inflation.(3)Backward looking term in hybrid specification is insignificant. (4)The change in the elasticity of substitution between labor and intermediate imported goods; ρ does not affect estimation results.(5)When markup over marginal cost increased from 10% to 40%, the coefficient on marginal cost decreases; meaning that the responsiveness of inflation to marginal cost declines.(6)Benchmark NKPC is a better proxy for inflation in Turkey, both in open economy and closed economy specifications. (7)Introducing open economy elements does not change results significantly.

2.2 Analysis with Quarterly Data

First, we employ Leith, Malley (2002,2007) approach in estimating Open Economy NKPC for Turkey. We deal with a particular case for the model where elasticity of substitution between labor and intermediate imported goods is equal to one, hence production technology is Cobb-Douglas.[5]

Hence,we can write Open economy NKPC as the following:

$$\begin{aligned} \pi_t &= \frac{\beta\theta}{\lambda}E_t\pi_{t+1} + \frac{\omega}{\lambda}\pi_{t-1} \\ &+ \frac{(1-\omega)(1-\theta)(1-\theta\beta)}{(1+(\Psi-1)\theta)\lambda} \\ &\left[\begin{array}{c} \hat{s}_t^L - (\psi-1)(\frac{i^s}{1+(1-\Psi)i^s})\hat{y}_t - \\ (\frac{i^s}{1+(1-\Psi)i^s})(\frac{\bar{s}}{\bar{s}+i^s})(\hat{W}_t - \hat{p}_t^f) \\ +(\frac{i^s}{1+(1-\Psi)i^s})(\hat{p}_t^d - \hat{p}_t^f) \end{array}\right] \\ where\ \lambda &= \omega + \theta\beta\omega + \theta - \omega\theta \end{aligned} \quad (31)$$

where $\hat{s}_t^L$ is the steady state deviation of (log of) labor share, i^s is steady state import

[5]Cobb-Douglas production function is a special case of CES production function where elasticity of substion between production factors is equal to one. In their paper, Leith, Malley(2002,2007) employ CES production function, and they freely estimate elasticity of substution as well as they consider two other cases where they let elasticity of substution to be 1 and 1/3 respectively.

share, $\bar{s}$ is steady state labor share, $\hat{y}_t$ is outputgap, $(\hat{W}_t - \hat{p}_t^f)$ is steady state deviation of price of labor relative to import prices,and $(\hat{p}_t^d - \hat{p}_t^f)$ is steady state deviation of terms of trade.

In this section, we estimate both the reduced form and the structural parameters of the model in Equation 31 for Turkey. These include the firms' steady-state discount factor, β, the probability that a firm can reset their price in period t, θ, and the proportion of firms following rule of thumb pricing behavior in time t, ω.

We use quarterly data for Turkey over the period 1990Q2-2006Q3. We use the ratio of (log of)labor compensation to nominal GDP to account for unit labor cost(ULC). Unit import cost (UIC) is defined as the ratio of intermediate good imports to nominal GDP. Output gap is calculated by HP filter using real GDP and output growth is calculated as quarterly percentage change in real GDP. Inflation is measured as quarterly percentage change in consumer price index. To calculate wage deflator we divided nominal wage to real wage and wage inflation is defined as percentage change in wage deflator. We derive import inflation similarly. Finally, to derive oil inflation we use quarterly percentage change of 3 spot price index.[6]

Before estimating Equation 31 for Turkey, it is necessary to obtain data for the steady-state ratio of imported goods used in production relative to GDP, $i^s = \bar{p}^f \bar{m}^f / \bar{p}^d \bar{y}$, and the steady-state labour share $\bar{s}$. To account for the possible change in the steady-state ratio of imported goods used in production relative to GDP,we use HP filtered trend of UIC rather than an average across the sample. This has the desired effect of appropriately capturing the changing importance of imported goods in production over time. For consistency, we also use HP filtered trend of ULC for the labour share and in calibrating Ψ to calculate the weights on the open economy terms in our NKPC. To obtain the latter, we followed the approach used in Leith, Malley(2002,2007) and we calculated Ψ as the following:

[6] See Table 14 for detailed data descriptions.

$$\psi = \frac{a}{\alpha - 1} / (\frac{\bar{s} + i^s}{1 + i^s}) \tag{32}$$

To calculate Ψ and when estimating equation 31 we assume α to be 11 which implies a mark-up over marginal costs, $\mu = \frac{\alpha}{1-\alpha} = 10\%$ as in Leith, Malley(2002,2007).

Since under rational expectations the error in the forecast of π_{t+1} is uncorrelated with information dated t and earlier, it follows from equation that

$$E_t \left\{ \pi_t - \left[\frac{\beta\theta}{\lambda} E_t \pi_{t+1} + \frac{\omega}{\lambda} \pi_{t-1} \frac{(1-\omega)(1-\theta)(1-\theta\beta)}{(1+(\Psi-1)\theta)\lambda} \hat{M}C_t \right] z_t \right\} = 0 \tag{33}$$

$$\begin{aligned} \hat{M}C_t &= \hat{s}_t^L - (\psi - 1)(\frac{i^s}{1 + (1-\Psi)i^s})\hat{y}_t - \\ & (\frac{i^s}{1 + (1-\Psi)i^s})(\frac{\bar{s}}{\bar{s} + i^s})(\hat{W}_t - \hat{p}_t^f) + (\frac{i^s}{1 + (1-\Psi)i^s})(\hat{p}_t^d - \hat{p}_t^f) \end{aligned} \tag{34}$$

where z_t is a vector of variables dated t and earlier (and, thus, orthogonal to the inflation surprise in period t+1). In this context and incorporating time-varying measures of $\bar{p}^f \bar{m}^f / \bar{p}^d \bar{y}, \Psi$ and s discussed above, the orthogonality condition given by equation 33 then forms the basis for estimating the model via Hansen's (1992) generalized method of moments (GMM) estimator.

Seasonality issue is handled with the commonly used program Census X12. Deviations from steady states are calculated by Hodrick-Prescott (HP) filter for all variables.

Since GMM estimation requires that underlying variables of the model and instruments used in estimation are stationary, we test all of the variables for a unit root in their data generation process. We use conventional Augmented Dickey Fuller Tests (ADF) by including a constant term only, and a linear trend together with a constant term in ADF equations.[7]

[7] We used Akaike Info Criterion to choose lag length.

We find no evidence, based on these tests, for a unit root in the variables in question at least at 10% significance level.[8]

2.2.1 Reduced Form Estimation

We begin by presenting estimates of the coefficients in baseline pure forward looking NKPC and hybrid NKPC. We refer to these estimates as reduced form since we do not try to identify the primitive parameters that underlie the slope coefficient λ. We then proceed to estimate the structural model and obtain an estimate of the key underlying primitive parameters;fraction of backward looking firms; ω degree of price rigidity; θ and the subjective discount factor β in the next section.

Our estimation procedure is based on following orthogonality conditions:

$$E_t\left\{(\pi_t - \gamma_f \pi_{t+1} - \lambda \hat{mc}_t) z_t\right\} = 0$$

$$\left\{(\pi_t - \gamma_f \pi_{t+1} - \gamma_b \pi_{t-1} - \lambda \hat{mc}_t) z_t\right\} = 0$$

Given this orthogonality condition, we estimate the model using GMM.

We use two instrument sets. First one includes four lags of inflation, output growth, output gap and oil inflation. Second vector of instruments includes four lags of inflation, oil inflation and import inflation.

Baseline Closed Economy NKPC For the baseline case, we use unit labor costs defined as $\log(\frac{WN}{PY})$ as a proxy for marginal costs as in Gali and Gertler (1999).

[8] See Table 15 for test results.

We report estimates for pure forward looking NKPC based on the two different vector of instruments at first and second rows of Table 16.

GMM estimate of inflation equation is the following:

$$\begin{aligned}\pi_t &= 1.02E_t\pi_{t+1} + 0.008\hat{m}c_t \\ &\quad\ (0.022) \qquad (0.003)\end{aligned}$$

where standard errors are shown in parentheses.

On the other hand, first and second columns of Table 17 presents GMM estimates of the Hybrid NKPC under two different vector of instrument. Hybrid NKPC for Turkey is given by:

$$\begin{aligned}\pi_t &= 0.17E_t\pi_{t+1} + 0.80\pi_{t-1} + 0.005\hat{m}c_t \\ &\quad\ (0.067) \qquad (0.067) \qquad (0.001)\end{aligned}$$

where standard errors are shown in parentheses. For both cases, pure forward looking and hybrid NKPC instrument set 2 (IS2) yields better results than instrument set 1(IS1). Hence, here we discuss results derived with instrument set 2. In both cases, coefficients are significantly different from zero and economically plausible. When we introduce backward looking inflation, coefficient on expected inflation falls below that of backward looking inflation and coefficient on marginal cost falls by 40%.

In either case , we do not reject the overidentifying restrictions.

Open Economy NKPC Subsequently, we estimate NKPC using open economy marginal cost (OMC) following Leith, Malley (2002,2007) approach as a proxy for marginal costs. We used the same instrument sets as in baseline model estimation; IS1 and IS2. Open economy NKPC is robust to these two different instrument sets. The estimates of coefficients in pure forward looking case are reasonably similar and we present here estimates derived with IS2.Hence, GMM estimate of the benchmark open economy inflation equation is the following:[9]

$$\begin{aligned} \pi_t &= \underset{(0.016)}{1.01} E_t \pi_{t+1} + \underset{(0.001)}{0.004} \hat{omc}_t \end{aligned}$$

where standard errors are shown in parentheses. Coefficient on expected inflation is reasonably similar to the closed economy counterpart. On the other hand, coefficient on marginal costs falls by 50%.

We, next, estimate hybrid NKPC using OMC, again with the same instrument sets. We present our results at third and fourth columns of Table 17. This time, model is not robust to choice of instruments; instrument set 2 yields significant estimates of the coefficients while model is rejected when we use instrument set 1.

GMM estimates of the open economy Hybrid NKPC for Turkey derived with IS2 is given by

$$\begin{aligned} \pi_t &= \underset{(0.058)}{0.35} E_t \pi_{t+1} + \underset{(0.056)}{0.62} \pi_{t-1} + \underset{(0.0008)}{0.002} \hat{omc}_t \end{aligned}$$

[9] For the results with instrument set 1 see row 3 of Table 16.

The coefficient on marginal cost decreases with respect to benchmark case and it is 50% less than its closed economy counterpart.

So far, from reduced form estimations we conclude that (1)Backward looking behavior dominates inflation. (2)When open economy elements are introduced, the coefficient on marginal cost falls by about 50%. (3)When we introduce backwardness into the NKPC, the coefficient on marginal cost falls by 50%.

2.2.2 Structural Parameters Estimation

We next estimate the structural parameters: ω;fraction of backward looking firms, θ; degree of price rigidity, β;and the subjective discount factor. As is well known, nonlinear GMM estimation using GMM is sometimes sensitive to the way the orthogonality conditions are imposed. For this reason, we employ two alternative specifications of the orthogonality conditions, which we refer to as specifications 1 and 2 respectively for each model.

$$E_t\left\{(\theta\pi_t - \theta\beta\pi_{t+1} - (1-\theta)(1-\beta\theta)\hat{m}c_t)z_t\right\} = 0 \quad (35)$$

$$E_t\left\{(\pi_t - \beta\pi_{t+1} - \theta^{-1}(1-\theta)(1-\beta\theta)\hat{m}c_t)z_t\right\} = 0 \quad (36)$$

$$E_t\left\{(\phi\pi_t - \theta\beta\pi_{t+1} - (1+(\Psi-1)\alpha)^{-1}(1-\theta)(1-\beta\theta)(1-\omega)\hat{m}c_t)z_t\right\} = 0 \quad (37)$$

$$E_t\left\{(\pi_t - \phi^{-1}\theta\beta\pi_{t+1} - \phi^{-1}(1+(\Psi-1)\alpha)^{-1}(1-\theta)(1-\beta\theta)(1-\omega)\hat{m}c_t)z_t\right\} = 0 \quad (38)$$

Further, for robustness check, we use two instrument set(The ones we used in reduced form estimation). First one includes four lags of inflation, output growth, output gap and oil inflation. Second vector of instruments include four lags of inflation, oil inflation and import inflation.

Baseline Closed Economy NKPC We use unit labor costs defined as $\log(\frac{WN}{PY})$ as a proxy for marginal costs as in Gali and Gertler (1999).

We report baseline pure forward looking model estimates based on the two different specifications of the orthogonality conditions at the first two rows of Table 18 and Table 19.At each table, the second and the third columns reports the two primitive parameters, θ and β and the fourth column reports Hansen's j statistic of overidentifying restrictions.

For both specifications the estimates are statistically different from zero. The subjective discount factor, β, is found to be highly significant. We find that degree of price rigidity θ; is about 0.90 it is robust across the different instrument sets under specification 1.Hence, the estimated average time prices are fixed is about 10 quarters. For specification 2, although all of the coefficients are found to be significant, none of them is economically plausible.

We present hybrid model estimates at the last row of Table 20.Closed economy hybrid NKPC is rejected by the data; subjective discount factor, β, is estimated to be 0.21 Nevertheless, there is strong evidence that this coefficient is equal to zero. On the other hand,.degree of price rigidity θ;the fraction of backward looking firms, ω, is estimated to be around 0.98, 0.97 respectively and they are statistically significant.

The model's overidentifying restrictions are not rejected under any specification.

Open Economy NKPC We use open economy marginal cost following Leith and Malley(2007) approach. We report open economy NKPC estimates based on the two different specifications of the orthogonality conditions at the third and fourth rows of Table 18 and Table 19. The second and the third columns report the two primitive parameters, θ and β. Next column displays Hansen's j statistic of overidentifying restrictions.

For both specifications and instrument sets the estimates are found to be highly significant. Nevertheless, only the estimates under specification 1 are economically admissible. For both instrument sets, the subjective discount factor, β is estimated to be slightly less than 1.Next, we find that degree of price rigidity θ; is about 0.94 it is robust across the different instrument sets under specification 1. This implies that average duration of a price is about 16 quarters.

We present hybrid model estimates at the first row of Table 20. In this case, subjective discount factor, β, is estimated to be 0.19. On the other hand,.degree of price rigidity θ;the fraction of backward looking firms, ω, is estimated to be around 0.99, %97 respectively and they are statistically significant. Hence, unlike the closed economy case, hybrid NKPC is accepted by the data.

2.2.3 Robustness Check: Alternative data set

To check robustness of our results, we estimate the model using an alternative data set. We use quarterly data for Turkey over the period 1991Q2:2006Q2. For constructing marginal cost, we use unit labor cost derived from index of wages per worker in manufacturing industry (W) ,Index of employment in Manufacturing Industry (N),Industrial Production Index (Y) and the consumer price index (P) ;Unit import cost derived from volume of imports index(M), import unit value index(Pim), the consumer price index (P) , Industrial Production Index (Y).[10] .Wage share is defined as W*N/P*Y and import share is defined as Pim*M/P*Y. Unit labor cost (ULC) is defined as log(W*N/P*Y) and Unit import cost (UIC) is defined as log(Pim*M/P*Y) Inflation is defined as logarithmic difference of consumer price index(CPI).[11]

Seasonality issue is handled with Census X12. Deviations from steady states are calculated by Hodrick-Prescott (HP) filter for all variables.

[10] See data appendix for detailed data descriptions and data sources.

[11] See Table 21 for detailed description of the data set.

We construct open economy marginal cost as in the previous section.

Table 22 and 23 presents the reduced form estimates for benchmark and hybrid NKPC, respectively. For baseline NKPC, we use four lags of inflation, output growth,output gap and wage inflation as instruments The estimated equation is the following:

$$\begin{aligned} \pi_t &= 0.89 E_t \pi_{t+1} + 0.004 o\hat{m}c_t \\ & \quad\; (0.043) \qquad (0.0009) \end{aligned}$$

For Hybrid NKPC, we use two to fourth lags of inflation, output growth, output gap, import inflation and oil inflation. The estimated equation is given by

$$\begin{aligned} \pi_t &= 0.37 E_t \pi_{t+1} + 0.59 \pi_{t-1} + 0.0004 o\hat{m}c_t \\ & \quad\; (0.078) \qquad (0.074) \qquad (0.0003) \end{aligned}$$

Table 24 presents the estimated structural parameters for both pure forward looking and Hybrid NKPC. The subjective discount factor, β is estimated to be 0.90 in the former and 0.39 in the latter. The degree of price rigidity θ is estimated to be around 0.99 in both specifications. The fraction of backward looking firms ω, is found to be 0.58. In both specifications, parameters are statistically significant and overidentifying restrictions are satisfied.

3 Conclusion

The estimates in this dissertation suggest that New Keynesian Phillips Curve offers insufficient explanations for the development of Turkish inflation over the period studied.

On monthly basis, we estimated NKPC using inflation expectations data by means of OLS. Structural parameters estimation results suggest that Hybrid form of NKPC is not supported by the data on both closed economy and open economy specifications. On the other hand, structural parameters of the pure forward looking NKPC are found to be significant and reasonably similar across open economy and closed economy specifications. In contrast, when we estimate reduced form equations, both hybrid and pure forward looking NKPC is refuted by the data, leading to negative estimates for the coefficient of marginal cost. We also considered a case where unit labor cost and open economy marginal cost enters the NKPC with a lag. In closed economy specification, the coefficients in reduced form equation are estimated to be different from zero in both hybrid and pure forward looking cases at least at 5% significance level. On the other hand, open economy specification yields similar results, however this time standard errors in estimation are large; coefficients are significant only at 10% level. The coefficient on forward looking inflation is greater than that of backward looking inflation on both open economy and closed economy specifications. Subsequently, to analyze the direct effect of oil prices on inflation dynamics, we estimated a NKPC where oil inflation enters into the equation in an ad hoc fashion as well as lagged unit labor costs. Based on this specification, we find that oil inflation is found to be significant at 5% level on pure forward looking model whereas it is significant at only 10% level when we introduce backwardness in the equation.

On quarterly basis, we used two alternative data sets. Since we do not have sufficient number of observations for the expected inflation, we used GMM as the estimation method this time.

For data set 1, to check robustness of our results to choice of instruments, we used (the same) two instrument sets at each estimation. Reduced form estimations suggest that unit labor cost based pure forward looking NKPC is not robust to choice of instruments since instrument set 1 yields insignificant estimates whereas instrument set 2 yields significant estimates. On the other hand open economy pure forward looking NKPC is robust across the same instrument sets. In each case, forward looking inflation and marginal cost is found to be highly significant and economically plausible. On the other hand, for the hybrid NKPC only instrument set 2 yields significant coefficient estimates for both closed economy and open economy specifications. In both cases, the coefficient on backward looking inflation is found to be highly significant and it is higher than that of forward looking inflation. The coefficient on unit labor cost is found to be significant whereas the coefficient on open economy marginal cost is found to be significant at only 10%level. To estimate structural parameters, we considered two alternative specifications for orthogonality conditions to check robustness across normalizations. Further, we used again two instrument sets to check robustness across different choice of instruments. For pure forward looking NKPC both open and closed economy specifications yield statistically significant and economically reasonable estimates and these estimates are robust across instrument sets. Although coefficients differ slightly across different specifications of orthogonality conditions, the ones estimated with specification 2 expressed as in Equation 36 are not theoretically admissible. Therefore we discuss here the results obtained with specification 1 expressed as in Equation 35.On the other hand Hybrid NKPC is estimated with instrument set 2 and under specification 2 , and we found that closed economy hybrid NKPC is refuted by the data whereas open economy HNKPC is accepted.

Subsequently, we estimated open economy NKPC with data set 2 and we found that structural parameters estimation yields significant estimates for both hybrid NKPC and pure forward looking NKPC whereas hybrid NKPC is rejected in reduced form estimation.

To sum up, monthly data suggests that pure forward looking NKPC is a better proxy for understanding Turkish inflation on both closed economy and open economy specifications. The subjective discount factor β, is estimated to be around 0,85 and degree of price rigidity, θ, is estimated to be around 0.99. On the other hand, quarterly data 1 suggest that for closed economy specification pure forward looking NKPC yields significant results. he subjective discount factor β, is estimated to be around 1 and degree of price rigidity, θ, is estimated to be around 0.90.On the contrary, for open economy specification, hybrid NKPC yields significant results. The subjective discount factor β is estimated to be 0,19 and degree of price rigidity, θ, is estimated to be 0.99 and the fraction of backward looking firms, ω, is estimated to be 0.97. Moreover, quarterly data set 2 yields similar results, hybrid open economy NKPC is accepted by the data and the subjective discount factor β is estimated to be around 0.4 and degree of price rigidity, θ, is estimated to be around 0.99, and the fraction of backward looking firms, ω, is estimated to be 0.59.[12]

Although the estimate of subjective discount factor β differs across data sets, the degree of price rigidity is estimated to be around 0.99 for open economy specifications. Although this parameter is found to be statistically significant, one should pause to think about its economic meaning: this implies that prices remain the same almost forever. This over estimated parameter value may be due to presence of unit root in the inflation data that we could not detect with the usual ADF tests. We leave the investigation of possible reasons to future research.

Another important difference to note that monthly data for both closed and open economy specifications as well as quarterly data for closed economy specification suggest that forward looking NKPC is a better proxy for Turkish inflation, whereas quarterly data for open economy specifications suggest that hybrid NKPC fits better to Turkish inflation. One likely reason for this result is that the time span used in estimation for monthly data and quarterly data is different. Monthly data starts from a specific date; August 2001 that consti-

[12]Table 25 and 26 presents a summary of reduced form, structural form estimates respectively.

tutes a starting point of a new monetary policy regime in Turkey whereas quarterly data goes back to beginning of 1990s.Based on this information, we may conclude that over the past twenty years, structural changes in the economy may have led to breaks in the relationship between real activity and inflation.

Based on the findings on this dissertation, we conclude that alternative specifications of NKPC should be considered to find more stable relation between real activity and inflation in Turkey.

4 Appendix

4.1 Appendix I: Analysis with Monthly Data

4.1.1 The Data

Table 1. Monthly data descriptions

	Description	Source
Wage(W)	Hourly earnings index	OECD Compendium 2006
Labor(L)	Index of Wages Per Production Hour	CB of Turkey
	Worked In Manufacturing Industry (1997=100)	
Output(Y)	Industrial production index (seas.adj.) (2000=100)	IFS database
Expected	Expected inflation of current Month	
inflation(Einf)	Survey of Expectations Descriptive Statistics	CB of Turkey
Price level(P)	Consumer Price Index (2000=100)	IFS database
Imports(M)	Volume of imports index(2000=100)	IFS database
Import	Import prıces Index(Pim) (2000=100)	IFS database
prices (Pim)		
Oil Prices	3 spot price index	IFS database

Table 2. Unit root test results for monthly data

Variable	**ADF test statistics**	**CV%1**	**CV%5**	**CV%10**	**Presence of unit root**
π	-2.720066	-2.601596	-1.945987	-1.613496	no unit root
omc	-2.791358	-2.609324	-1.947119	-1.612867	no unit root

Notes: "*" means rejection of unit root at 5% significance level.

mnemonics	
omc	Open economy marginal cost derived as in Leith,Malley(2002,2007)
π	Seasonally adjusted inflation series

4.1.2 Reduced Form Estimation

Table 3.Reduced form .OLS estimation results of NKPC with unit labor cost and open economy marginal cost

	γ_f	γ_b	λ	White Heteroskedasticity Test:
M1	0.824012	-	-2.129231	25.75129
	(0.049878)	-	(1.578280)	[0.000100]
	[0.0000]	-	[0.1829]	
M2	0.619078	0.218539	-2.512548	26.37723
	(0.140487)	(0.149537)	(1.563148)	[0.001772]
	[0.0001]	[0.1499]	[0.1140]	
M3	0.847114	-	-0.006460	38.93399
	(0.049678)	-	(0.006071)	[0.000000]
	[0.0000]	-	[0.2920]	
M4	0.594083	0.283861	-0.010485	40.76493
	(0.143514)	(0.158263)	(0.006311)	[0.000006]
	[0.0001]	[0.0787]	[0.1027]	

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2)M1 refers to benchmark closed economy NKPC,M2 refers to hybrid closed economy NKPC ,M3 refers to benchmark open economy NKPC and M4 refers to hybrid open economy NKPC.

Table 4a.OLS estimation results of NKPC with lagged unit labor cost and open economy marginal cost				
	γ_f	γ_b	λ_{-1}	White Heteroskedasticity Test:
M1	0.844139		3.017533	16.43669
	(0.049339)		(1.534996)	[0.005702]
	[0.0000]		[0.0545]	
M2	0.553385	0.341259	4.260741	17.78463
	(0.139292)	(0.153630)	(1.584123)	[0.037756]
	[0.0002]	[0.0306]	[0.0095]	
M3*	0.816444	-	0.009750	7.999553
	(0.058542)		(0.005491)	[0.156260]
	[0.0000]		[0.0814]	
M4*	0.612279	0.232771	0.011001	10.50476
	(0.127580)	(0.132067)	(0.005126)	[0.311187]
	[0.0000]	[0.0837]	[0.0365]	

b.OLS estimation using indexed unit labor cost.(lagged)			
	γ_f	γ_b	λ_{-1}
M1	0.854851		0.008378
	(0.048578)		(0.004151)
	[0.0000]		[0.0485]
M2	0.549076	0.356332	0.011836
	(0.139089)	(0.152666)	(0.004259)
	[0.0002]	[0.0233]	[0.0075]

Notes:(1)"*" indicates that reported statistics are white Heteroskedasticity-consistent Standard Errors

(2)Standard errors are in parentheses. P-values are in brackets.

(3)M1 refers to baseline closed economy NKPC, M2 refers to hybrid closed economy NKPC ,M3 refers to baseline open economy NKPC and M4 refers to hybrid open economy NKPC.

Table 5. OLS estimation of NKPC with ad hoc oil inflation variable

	γ_f	γ_b	$\lambda_1(ulccap(-1))$	$\lambda_2(\inf oil)$	White Test
M1	0.857800	-	3.328726	2.394056	28.28085
	(0.047400)		(1.503871)	(1.223892)	(0.000856)
	[0.0000]		[0.0311]	[0.0556]	
M2	0.582045	0.320849	4.449128	2.046236	29.75497
	(0.138036)	(0.151453)	(1.550521)	(1.197492)	(0.008247)
	[0.0001]	[0.0388]	[0.0059]	[0.0933]	

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2)M1 refers to baseline model whereas M2 refers to hybrid model.

Table 6. OLS estimation of restricted model:($\gamma_f + \gamma_b$)

real variable	$\gamma = \gamma_f$	1-$\gamma = \gamma_b$	λ	λ_2(inf oil)
ulccap	0.624721		1.672184	-
	(0.150153)		(1.645652)	
	[0.0001]		[0.3141]	
omc	0.564482		-0.014375	-
	(0.147171)		(0.006209)	
	[0.0003]		[0.0244]	
ulccap(-1)	0.525740		5.172763	-
	(0.141465)		(1.550122)	
	[0.0005]		[0.0015]	
omc(-1)	0.611000		0.009523	-
	(0.148882)		(0.006259)	
	[0.0001]		[0.1339]	
ulccap(-1)+infoil	0.557034		5.256398	0.019795
	(0.140785)		(1.528857)	(0.012263)
	[0.0002]		[0.0011]	[0.1123]

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

mnemonics	
ulccap	HP filtered unit labor cost
omc	Open economy marginal cost derived as in Leith,Malley(2002,2007)
infoil	Monthly percentage change in oil prices

Table 7.OLS estimation of open economy NKPC

with a markup of 40%(i.e.$\mu = 1.4, \rho = 1/3$)

	γ_f	γ_b	λ
M1	0.847730	-	-0.000823
	(0.050129)		(0.000886)
	[0.0000]		[0.3570]
M2	0.604921	0.284617	
	(0.143508)	(0.158058)	(0.000921)
	[0.0001]	[0.0774]	[0.1414]
M3*	0.823688		0.001445
	(0.056966)		(0.000770)
	[0.0000]		[0.0657]
M4*			0.001601
	(0.130996)	(0.136712)	(0.000720)
	[0.0000]	[0.0851]	[0.0304]

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2) M1 refers to baseline open economy NKPC, M2 refers to hybrid open economy NKPC, M3 refers to baseline open economy NKPC with lagged marginal cost, M4 refers to hybrid open economy NKPC with lagged marginal cost.

(3)"*" indicates that reported statistics are white Heteroskedasticity-consistent Standard Errors

Table 8.OLS estimation of open economy NKPC with $\rho = 1$ and $\mu = 1.1$			
	γ_f	γ_b	λ
M1	0.847114		-0.006460
	(0.049678)		(0.006071)
	[0.0000]		[0.2920]
M2	0.569503	0.614893	-0.007312
	(0.044776)	(0.069612)	(0.003899)
	[0.0000]	[0.0000]	[0.0663]
M3*	0.826920		0.010104
	(0.057427)		(0.005438)
	[0.0000]		[0.0685]
M4*	0.610606	0.245326	0.011359
	(0.129493)	(0.135334)	(0.005068)
	[0.0000]	[0.0754]	[0.0291]

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2) M1 refers to baseline open economy NKPC, M2 refers to hybrid open economy NKPC, M3 refers to baseline open economy NKPC with lagged marginal cost, M4 refers to hybrid open economy NKPC with lagged marginal cost.

(3)"*" indicates that reported statistics are white Heteroskedasticity-consistent Standard Errors

Table 9.OLS estimation of open economy NKPC with $\rho = 1$ and $\mu = 1.4$			
	γ_f	γ_b	λ
M1	0.847671	-	-0.000822
	(0.071398)		(0.001554)
	[0.0000]		[0.5988]
M2	0.604894	0.284544	-0.001373
	(0.131530)	(0.152696)	(0.001548)
	[0.0000]	[0.0679]	[0.3789]
M3*	0.823778		0.001445
	(0.056990)		(0.000769)
	[0.0000]		[0.0656]
M4*	0.612266	0.239703	0.001601
	(0.131038)	(0.136728)	(0.000719)
	[0.0000]	[0.0853]	[0.0303]

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2) M1 refers to baseline open economy NKPC, M2 refers to hybrid open economy NKPC, M3 refers to baseline open economy NKPC with lagged marginal cost, M4 refers to hybrid open economy NKPC with lagged marginal cost.

(3)"*" indicates that reported statistics are white Heteroskedasticity-consistent Standard Errors

Table 10. OLS estimation of NKPC with outputgap as a driving force of inflation			
	γ_f	γ_b	λ
M1	0.679086	0.182872	0.004787
	(0.132580)	(0.142665)	(0.026403)
	[0.0000]	[0.2046]	[0.8567]
M2	0.834839	-	-0.002425
	(0.053304)		(0.025926)
	[0.0000]		[0.9258]

Notes:(1)Standard errors are in parentheses. P-values are in brackets.

(2) M1 refers to hybrid NKPC, M2 refers to baseline NKPC.

4.1.3 Structural Parameters Estimation

Table 11. OLS estimation of structural parameters of baseline NKPC

	β	ω	θ
M1	0.842574		0.996657
	0.050940		0.027247
	0.0000		0.0000
M2	0.940600	-0.589955	0.973268
	0.026289	0.086954	0.021404
	0.0000	0.0000	0.0000
M3	0.854741		0.991846
	0.049378		0.006052
	0.0000		0.0000
M4	0.922815	-0.615009	1.004353
	0.024784	0.097853	0.006355
	0.0000	0.0000	0.0000

Notes: (1)Standard errors are in parentheses. P-values are in brackets.

(2)M1,M2 refers to estimates of baseline and hybrid NKPC with unit labor cost

M3,M4 refers to estimates of baseline and hybrid open economy NKPC respectively.

4.2 Appendix II:Analysis with Quarterly Data

4.2.1 The Data

Table 14. Quarterly Data Set 1 Descriptions

	Description	Source
Wage(W)	Wage deflator computed as nomwage/realwage	
Labor Compensation	Labor Compensation	CB of Turkey
NY	nominal gdp	CB of Turkey
Output(Y)	real gdp	CB of Turkey
Price level(P)	Consumer Price Index (2000=100)	CB of Turkey
Imports(M)	Intermediate good imports	CB of Turkey
Import prices (Pim)	Import deflator	CB of Turkey
Oil Prices	3 spot price index	IFS database

Table 15. ADF test results

Variable	ADF test statistics	CV%1	CV%5	CV%10	$H_o : unitroot$
inf_sa	-5.689986	-4.103198	-3.479367	-3.167404	No unit root
mc					
winf	-3.169251	-4.110440	-3.482763	-3.169372	No unit root**
impinf_sa	-7.086930	-4.100935	-3.478305	-3.166788	No unit root
oilinf	-4.026238	-4.121303	-3.487845	-3.172314	No unit root
gy	-5.475559	-4.107947	-3.481595	-3.168695	No unit root

Notes: "*" means rejection of unit root at 5% significance level.

mnemonics	
mc	Marginal cost derived as in Leith,Malley(2002,2007)
inf_sa	seasonally adjusted inflation series
winf	wage deflator
impinf_sa	Seasonally adjusted import deflator
oilinf	oil inflation
ygrowth	percentage change in real gdp(sa)

4.2.2 Reduced Form Estimation

Table16. GMM estimates of reduced form benchmark NKPC

		γ_f	λ	j-statistics
IS1	* Closed economy NKPC	0.004325	1.016643	0.185648
		(0.002619)	(0.016998)	
		[0.1041]	[0.0000]	
IS2	*Closed economy NKPC	1.017801	0.008083	0.151710
		(0.022467)	(0.003051)	
		[0.0000]	[0.0104]	
IS1	*Open economy NKPC	1.010587	0.002553	0.165835
		(0.012569)	(0.000662)	
		[0.0000]	[0.0003]	
IS2	*Open Economy NKPC	1.004524	0.003534	0.153181
		(0.016929)	(0.001244)	
		[0.0000]	[0.0062]	

Notes:(1) Note:Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Four lags of inflation,output growth,outputgap,oil inflation.

Instrument set 2(IS2):Four lags of inflation,oil inflation,import inflation

(3)Asterix (*) shows that prewhitening is used.

Table17. GMM estimates of reduced form Hybrid NKPC

		γ_f	γ_b	λ	j-statistics
IS1	Closed economy NKPC*	0.131905	0.807279	0.001356	0.136680
		(0.074696)	(0.075090)	(0.001797)	
		[0.0829]	[0.0000]	[0.4537]	
IS2	Closed economy NKPC*	0.179665	0.802036	0.004458	
		(0.067000)	(0.067260)	(0.001559)	
		[0.0096]	[0.0000]	[0.0059]	
IS1	Open economy NKPC*	0.148709	0.792070	0.000112	
		(0.068665)	(0.067856)	(0.000513)	
		[0.0346]	[0.0000]	[0.8286]	
IS2	Open Economy NKPC*	0.354197	0.622496	0.001553	0.114176
		(0.058860)	(0.056528)	(0.000881)	
		[0.0000]	[0.0000]	[0.0833]	

Notes:(1) Note:Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Four lags of inflation,output growth,outputgap,oil inflation.

Instrument set 2(IS2):Four lags of inflation,oil inflation,import inflation

(3)Asterix (*) shows that prewhitening is used.

4.2.3 Structural Parameters Estimation

Table 18. GMM estimates of structural parameters under specification 1

		β	θ	j-statistics
IS1	Baseline NKPC*	1.042614	0.898639	0.188508
		(0.023553)	(0.020080)	
		[0.0000]	[0.0000]	
IS2	Baseline NKPC	1.013672	0.897768	0.128900
		(0.030830)	(0.020362)	
		[0.0000]	[0.0000]	
IS1	Open Economy NKPC($\mu = 1.1, \rho = 1$)	0.999883	0.937591	0.186761
		(0.018806)	(0.011524)	
		[0.0000]	[0.0000]	
IS2	Open Economy NKPC($\mu = 1.1, \rho = 1$)	0.990221	0.937209	0.115397
		(0.024518)	(0.012473)	
		[0.0000]	[0.0000]	

Notes:(1) Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Four lags of inflation,output growth,outputgap,oil inflation.

Instrument set 2(IS2):Four lags of inflation,oil inflation,import inflation

Table 19. GMM estimates of structural parameters under specification 2				
		β	θ	j-statistics
IS1	Baseline NKPC*	1.016579	1.059487	0.185648
		(0.016999)	(0.020081)	
		[0.0000]	[0.0000]	
IS2	Baseline NKPC*	1.018361	1.084694	0.151599
		(0.022563)	(0.021812)	
		[0.0000]	[0.0000]	
IS1	Open Economy NKPC($\mu = 1.1, \rho = 1$)*	1.010603	1.046391	0.165833
		(0.012566)	(0.007800)	
		[0.0000]	[0.0000]	
IS2	Open Economy NKPC($\mu = 1.1, \rho = 1$)*	1.004456	1.058949	0.153118
		(0.016944)	(0.014142)	
		[0.0000]	[0.0000]	

Notes:(1) Note:Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Four lags of inflation,output growth,outputgap,oil inflation.

Instrument set 2(IS2):Four lags of inflation,oil inflation,import inflation

(3)Asterix (*) shows that prewhitening is used.

Table 20. GMM estimates of structural parameters of HNKPC estimated under specification 1				
	β	θ	ω	j-statistics
Open Economy HNKPC($\mu = 1.1, \rho = 1$)	0.186610	0.991119	0.973411	0.130257
	(0.109441)	(0.009675)	(0.021899)	
	[0.0937]	[0.0000]	[0.0000]	
Baseline HNKPC	0.106174	0.957922	0.972667	0.115809
	(0.043298)	(0.031220)	(0.021145)	
	[0.6850]	[0.0000]	[0.0000]	

Notes:(1) Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 2(IS2) is used:Four lags of inflation,oil inflation,import inflation

4.2.4 Robustness Check: Alternative data set

Table 21. Data set 2 descriptions		
	Description	Source
Labor(L)		CB of Turkey
Wage(W)	Index of Wages Per Production Hour	CB of Turkey
	Worked In Manufacturing Industry (1997=100)	
Output(Y)	Industrial production index (seas.adj.) (2000=100)	IFS database
Price level(P)	Consumer Price Index (2000=100)	IFS database
Imports(M)	Volume of imports index(2000=100)	IFS database
Import prices (Pim)	Import prices Index(Pim) (2000=100)	IFS database
Oil Prices	3 spot price index	IFS database

Table 22. GMM estimates of reduced form baseline open economy NKPC			
	γ_f	λ	
IS1	0.897315	0.003369	0.112477
	(0.043898)	(0.000993)	
	[0.0000]	[0.0012]	
IS2	0.901953	0.001466	0.094306
	(0.038212)	(0.000636)	
	[0.0000]	[0.0248]	

Notes:(1)() Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Four lags of inflation,output growth,outputgap,wage inflation.

Instrument set 2(IS2):Four lags of inflation,output growth,outputgap.

Table 23. GMM estimates of reduced form open economy hybrid NKPC				
	γ_f	γ_b	λ	J statistics
IS1	0.377768	0.597321	0.000489	0.139581
	(0.078686)	(0.074760)	(0.000294)	
	[0.0000]	[0.0000]	[0.1014]	
IS2	0.307374	0.675194	0.000405	0.116270
	(0.103548)	(0.104460)	(0.000330)	
	[0.0043]	[0.0000]	[0.2250]	

Notes:(1) Standard errors are in parentheses. P-values are in brackets.

(2)Instrument set 1(IS1):Two to four lags of inflation,output growth,outputgap,import inflation, oil inflation.

Instrument set 2(IS2):Four lags of inflation,output growth,outputgap.

Table 24. GMM estimates of structural open economy NKPC				
	β	θ	ω	j statistics
M1	0.901259	0.986785	-	0.093489
	(0.038353)	(0.003451)	-	
	[0.0000]	[0.0000]	-	
M2	0.398067	0.998100	0.581709	0.142687
	(0.081277)	(0.001284)	(0.077385)	
	[0.0000]	[0.0000]	[0.0000]	

Notes:(1) Standard errors are in parentheses. P-values are in brackets.

(2)M1 refers to baseline open economy NKPC. Instrument set used for estimation is four lags of inflation,output growth,outputgap.

M2 refers to hybrid open economy NKPC. Instrument set used for estimation is two to four lags of inflation, output growth,outputgap, import inflation and oil inflation.

Table 25.Summary of our Findings 1:Reduced Form Estimates			
a. Closed Economy Estimates			
	γ_f	γ_b	λ
M1	0.844139 (0.049339) [0.0000]		3.017533 (1.534996) [0.0545]
M2	1.017801 (0.022467) [0.0000]		0.008083 (0.003051) [0.0104]
M3	0.553385 (0.139292) [0.0002]	0.341259 (0.153630) [0.0306]	4.260741 (1.584123) [0.0095]
M4	0.179665 (0.067000) [0.0096]	0.802036 (0.067260) [0.0000]	0.004458 (0.001559) [0.0059]

Notes:(1) P-values are in brackets.

(2)M1 refers to baseline closed economy NKPC estimated with monthly data.

M2 refers to baseline closed economy NKPC estimated with quarterly data set 1.

M3 refers to hybrid closed economy NKPC estimated with monthly data.

M2 refers to hybrid closed economy NKPC estimated with quarterly data set 1.

b. Open economy estimates			
	γ_f	γ_b	λ
M1	0.816444 (0.058542) [0.0000]		0.009750 (0.005491) [0.0814]
M2	1.004524 (0.016929) [0.0000]		0.003534 (0.001244) [0.0062]
M3	0.897315 (0.043898) [0.0000]		0.003369 (0.000993) [0.0012]
M4	0.612279 (0.127580) [0.0000]	0.232771 (0.132067) [0.0837]	0.011001 (0.005126) [0.0365]
M5	0.354197 (0.058860) [0.0000]	0.622496 (0.056528) [0.0000]	0.001553 (0.000881) [0.0833]
M6	0.377768 (0.078686) [0.0000]	0.597321 (0.074760) [0.0000]	0.000489 (0.000294) [0.1014]

Notes:(1) P-values are in brackets.

(2)M1 refers to baseline open economy NKPC estimated with monthly data.

M2 refers to baseline open economy NKPC estimated with quarterly data set 1.

M3 refers to baseline open economy NKPC estimated with quarterly data set 2.

M4 refers to hybrid open economy NKPC estimated with monthly data.

M5 refers to hybrid open economy NKPC estimated with quarterly data set 1.

M6 refers to hybrid open economy NKPC estimated with quarterly data set 2.

Table 26.Summary of our Findings 2:Structural Parameter Estimates

a. Closed **form estimates**

	β	θ	ω	λ
M1	0.842574 0.050940 0.0000	0.996657 0.027247 0.0000		0,003009027
M2	1.013672 (0.030830) [0.0000]	0.897768 (0.020362) [0.0000]		0,113585746
M3	0.940600 (0.026289) [0.0000]	0.973268 (0.021404) [0.0000]	-0.589955 (0.086954) [0.0000]	0,156545534
M4	0.106174 (0.043298) [0.6850]	0.957922 (0.031220) [0.0000]	0.972667 (0.021145) [0.0000]	7,0112E-05

Notes:(1) P-values are in brackets.

(2)M1 refers to baseline closed economy NKPC estimated with monthly data.

M2 refers to baseline closed economy NKPC estimated with quarterly data set 1.

M3 refers to hybrid closed economy NKPC estimated with monthly data.

M4 refers to hybrid closed economy NKPC estimated with quarterly data set 1.

b. Open economy estimates				
	β	θ	ω	λ
M1	0.854741 0.049378 0.0000	0.991846 0.006052 0.0000		0,008221034
M2	0.990221 (0.024518) [0.0000]	0.937209 (0.012473) [0.0000]		0,066997863
M3	0.901259 (0.038353) [0.0000]	0.986785 (0.003451) [0.0000]		0,013391975
M4	0.922815 0.024784 0.0000	1.004353 0.006355 0.0000		-0,026022946
M5	0.186610 (0.109441) [0.0937]	0.991119 (0.009675) [0.0000]	0.973411 (0.021899) [0.0000]	7,05206E-06
M6	0.398067 (0.081277) [0.0000]	0.998100 (0.001284) [0.0000]	0.581709 (0.077385) [0.0000]	0,000270917

Notes:(1) P-values are in brackets.

(2)M1 refers to baseline open economy NKPC estimated with monthly data.

M2 refers to baseline open economy NKPC estimated with quarterly data set 1.

M3 refers to baseline open economy NKPC estimated with quarterly data set 2.

M4 refers to hybrid open economy NKPC estimated with monthly data.

M5 refers to hybrid open economy NKPC estimated with quarterly data set 1.

M6 refers to hybrid open economy NKPC estimated with quarterly data set 2.

5 References

Batini N, Jackson B, Nickell S (2005) An open-economy New Keynesian Phillips Curve for the UK. Journal of Monetary Economics 52:1061–1071

Calvo G (1983) Staggered prices in a utility maximising framework. Journal of Monetary Economics 12(3):383–398

Galí J, Gertler M (1999) Inflation dynamics: a structural econometric analysis. Journal of Monetary Economics 44:195–222

Galí J, Gertler M, López-Salido JD (2001) European inflation dynamics. European Economic Review 45:1237–1270

Galí J, López-Salido JD (2001) A new Phillips Curve for Spain. BIS Papers, No. 3

Genberg H, and Pauwels L (2005) An Open-Economy New Keynesian Phillips Curve: Evidence from Hong Kong . Pacific Economic Review 10(2):261-277.

Hansen L (1982) Large sample properties of generalized method of moments estimators. Econometrica 50:1029–1054

Layard, R., Nickell, S., Jackman, R., 1991. Unemployment. Macroeconomic Performance and the Labor Market. Oxford University Press, Oxford.

Leith C, Malley J (2003) Estimated open economy New Keynesian Phillips Curves for the G7.CESifoWorking Paper, No. 834

Rotemberg, J.J., 1982. Sticky prices in the United States. Journal of Political Economy 90 (6), 1187–1211.

Yazgan M.E., Yılmazkuday H.(2005) Inflation Dynamics of Turkey: A Structural Estimation.Studies in Nonlinear Dynamics & Econometrics 9(1)