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# Inflation Dynamics in Turkey: In Pursuit of a Domestic Cost Measure

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# Inflation Dynamics in Turkey: In Pursuit of a Domestic Cost Measure

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## Abstract

We provide Bayesian estimates of an empirical model of consumer price inflation for Turkey based on the hybrid New Keynesian Phillips Curve. We decompose real marginal costs into domestic and foreign components and focus particularly on identifying the effect of the domestic component. We find that the baseline model which uses output gap as a measure of domestic real marginal costs does a better job in explaining consumer price inflation compared to alternative models which incorporate real unit labor costs. On the other hand, estimations for services inflation point to the importance of real unit labor costs for this sector.

**Keywords:** Inflation, Real marginal costs, Phillips Curve, Turkey

**JEL codes:** E12, E31, E37

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## 1. Introduction

Understanding inflation dynamics is of utmost importance for an inflation targeting central bank. In this study, we estimate empirical models of inflation based on the hybrid New Keynesian Phillips Curve (NKPC) to shed light on inflation dynamics in Turkey. Although the impact of foreign cost measures on Turkish inflation is well-established, there is little work done on the impact of domestic costs. We aim to fill this gap by analyzing possible proxies for domestic cost pressures in an empirical setup inspired by the NKPC. Our methodology makes it possible to obtain estimates for real marginal cost and its domestic and foreign components, which are not directly observed in the data.

The hybrid NKPC simply states that inflation today is a function of lagged inflation, expected future inflation and real marginal cost. In this theoretical setup, inflation refers to *domestic* inflation and real marginal cost refers to the cost of producing an additional unit of the *domestic* good. Accordingly, the gross domestic product (GDP) deflator is commonly used as a measure of inflation in empirical studies that estimate the NKPC[2]. In this study, we measure inflation using the Consumer Price Index (CPI) instead. This is based on the fact that, in Turkey, inflation target is set in terms of the CPI, and accordingly the priority is given to the grasp of the dynamics of consumer price inflation.[3] Although the theoretical background of this study comes from the NKPC, we attach more weight to empirical aspects, trying to understand the determinants of the observed behavior of the most commonly used inflation measure in Turkey.

Output gap and real unit labor cost are widely used in the estimations of the NKPC as real marginal cost indicators. However, these two measures often lead to different estimates of the relative importance of backward and forward looking behavior for inflation. Existing studies on the NKPC for Turkey mainly differ due to the use of different real marginal cost indicators as well as different samples. Using consumer price inflation and labor income share as a real marginal cost measure, Yazgan and Yılmazkuday (2005) show that Turkish inflation dynamics are best explained by a purely forward looking NKPC instead of a hybrid one between 1988Q2 and 2003Q1.[4] In a more recent study, Agénor and Bayraktar (2010) find that the extended version of the hybrid NKPC is a better predictor of consumer price inflation in Turkey from 1981Q1 to 2006Q2. Their findings also suggest that output gap is insignificant, and backward looking price setting is predominant. On the other hand, using the CPI and a marginal cost index between 2005:01 and 2009:12, Saz (2011) presents evidence for the hybrid NKPC in Turkey, where the forward looking component has a relatively a larger coefficient and real marginal costs have a significant role.

[2] For example see Galí and Gertler (1999) and Muto (2009).
[3] A similar approach is used in Céspedes et al. (2005), Vašíček (2011) and Zhang (2013).
[4] This seems to be a surprising result given the high degree of persistence in inflation for Turkey in that period. For example, Agénor and Bayraktar (2010) estimate a quite high inflation persistence, 0.9-0.95, which is measured by estimated coefficients from AR(1) and AR(2) processes, over the period 1981Q1-2006Q2.

In this study, we estimate empirical models of consumer price inflation based on a hybrid NKPC in a Bayesian setting. We construct a cost measure divided into foreign and domestic components. The foreign cost measure is estimated as a function of import prices in domestic currency whereas the domestic cost measure is modeled with the output gap in the baseline case and with alternative variables in other specifications. To be more precise, we use a variety of real unit labor cost (ULC) indicators and a linear combination of output gap and ULC that can be considered as capturing non-labor and labor costs. Our results suggest that output gap is a better proxy to measure domestic cost pressures on consumer price inflation compared to real unit labor cost. When we repeat the analysis for inflation in services, which are largely domestically produced, we find an important role for real unit labor cost.

## 2. Labor Cost Indicators in Turkey

The New Keynesian theory postulates that inflation depends on a discounted sum of future real marginal costs. Theoretically, it is possible to show that real marginal cost is proportionate to output gap under certain assumptions.[5] Accordingly, most of the empirical work on the NKPC uses output gap as an indicator of the real marginal cost. However, as argued by Galí and Gertler (1999), there are certain drawbacks of using output gap in NKPC estimations. Firstly, marginal cost directly covers the impact of productivity gains on inflation which is a point that traditional output gap measures often miss. Secondly, theoretical conditions under which output gap is proportionate to real marginal cost might not be satisfied. Finally, there might be a discrepancy between the two measures in the data especially in terms of their lead-lag relationship.[6] In this respect, it is important to investigate whether using other measures of real marginal costs contribute to the analysis of inflation in Turkey.

Real marginal costs are not directly observable. The common approach in the literature is to assume a Cobb-Douglas production function with capital and labor, which renders real marginal cost equivalent to real unit labor cost, which in turn is equivalent to labor income share. Real unit labor cost, ULC, is given by:

$$\mathrm{ULC} = \frac{W/P}{Y/L} \tag{1}$$

where $W$ denotes the wage rate, $P$ is the CPI, $Y$ is the real output and $L$ is employment.

We consider two different series for the wage rate $W$; minimum wage rate and total nonfarm gross wage payment per employee. Hence, we have two different ULC series, namely

[5] See Rotemberg and Woodford (1999).

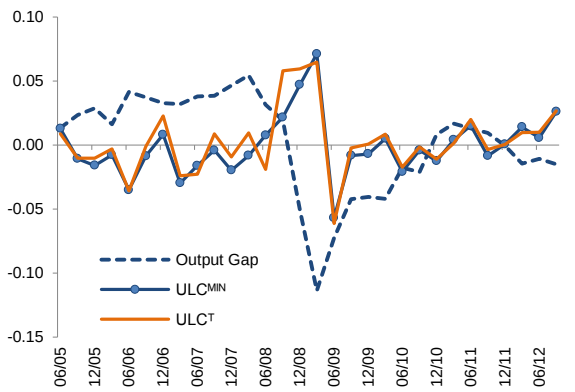
[6] In the case of the United Sates, NKPC generates counter-intuitive predictions when the output gap is used as a measure of inflationary pressure, which led Galí and Gertler (1999) to search for a more suitable proxy for real marginal costs. In recent years, based on the findings of Galí and Gertler, the number of studies estimating the NKPC with labor income share as a proxy of marginal cost has increased considerably. However, some studies strongly debate against this result. Among those Rudd and Whelan (2007) argue that the labor income share version of the model provides a very poor description of the inflation behavior and that labor share is a weak proxy as it tends to be countercyclical.

$ULC^{MIN}$ and $ULC^{T}$, calculated according to equation (1).[7] $ULC^{MIN}$ stands for the real unit labor cost computed by dividing real minimum wage rate by labor productivity while $ULC^{T}$ represents the real unit labor cost calculated by dividing nonfarm gross real wage rate by labor productivity.[8]

Following the literature, we start by using the traditional output gap as a domestic cost measure and take the model with output gap as the baseline. Then, we employ real unit labor cost as an alternative domestic cost measure. This is motivated by the fact that labor costs make up a non-negligible part of total operating costs of firms across the whole economy in Turkey.

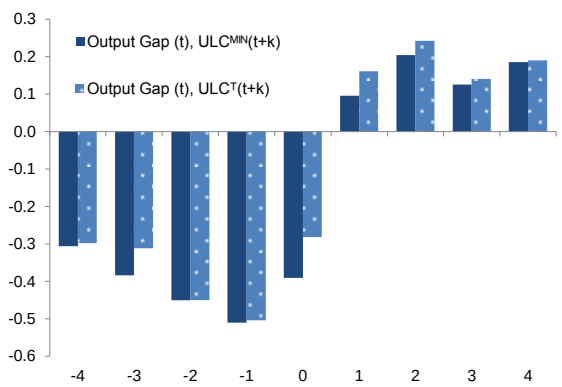
Figure 1 plots $ULC^{MIN}$ and $ULC^{T}$ series alongside a measure of the output gap derived by using a New Keynesian small open economy model estimated for the Turkish economy (Alp et al., 2012).[9] Figure 1 highlights some important features of the data in question. Firstly, both ULC measures move closely together. In particular, the contemporaneous correlation between $ULC^{MIN}$ and $ULC^{T}$ is 0.92. Secondly, output gap is more persistent than ULC measures. Thirdly, ULC measures tend to lag the output gap, which is also the case for the US as documented by Galí and Gertler (1999). Due to the sluggish response of labor income share to output gap, the contemporaneous relation between the two measures is negative[10] (Figure 2), which contradicts the theoretical prediction of the standard sticky price framework in the absence of wage rigidities. These observations suggest that output gap and real unit labor cost might have different information content for short-term inflation dynamics.

**Figure 1: Output Gap and Real Unit Labor Costs**




*Notes*: $ULC^{MIN}$ and $ULC^{T}$ represent real unit labor cost series computed using the minimum wage rate and total nonfarm gross wage payments over total employment, respectively.

**Figure 2: Cross-Correlations of Real Unit Labor Costs and Output Gap**




*Notes*: Horizontal axis shows the values for *k*. Correlations are calculated using the data between 2005Q2-2012Q3.

[7] As an alternative to the minimum wage rate and non-farm gross wage payments, we also considered the wage rate in the manufacturing sector when calculating ULC, denoted by $ULC^{MAN}$. Table 2 shows that sum of squared errors of the NKPC estimation with $ULC^{MAN}$ is quite close to that of the one with $ULC^{MIN}$ or $ULC^{T}$. However, manufacturing industry represents a limited part of the whole economy. Therefore, we choose to discuss the results of NKPC estimations with $ULC^{MIN}$ and $ULC^{T}$ in Section 4.

[8] An alternative way to compute ULC is to divide total compensation to employees by nominal GDP, i.e. ULC=WL/PY, which is essentially the same as equation (1). We prefer the formula with the wage rate instead of total compensation as we also use the minimum wage rate in calculating the ULC.

[9] Details about the derivation of the output gap is given in section 3.2.1.

[10] This negative relationship is mostly apparent during the global financial crisis and towards the end of the sample.

In countries like Turkey, there is a large foreign component in total production costs due to the high share of raw materials and intermediate inputs which, to a large extent, are imported from abroad. For example, according to Karadaş et al. (2006), costs associated with imported raw materials and equipments constituted of about 36 percent of total operating costs of manufacturing firms in 2004. Together with energy, this accounted for about 43 percent of total costs on average. The weight of the foreign cost component could be even higher when we take into account the import content of the domestic intermediate and capital goods. Accordingly, studies that analyze Turkish inflation dynamics find an important role for import prices and exchange rate in driving the CPI inflation (e.g. Kara and Öğünç (2008), Kara and Öğünç (2012)). In our analysis, we relate these two variables to foreign costs and largely focus on obtaining a domestic cost measure.

## 3. Modeling and Estimation

### 3.1. Baseline Model

We build an empirical model based on the hybrid New Keynesian Phillips curve specification which is widely used in the literature:[11]

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda rmc_t + \varepsilon_t^{\pi}, \qquad \gamma_b + \gamma_f = 1. \tag{2}$$

Equation (2) is closely related to the hybrid New Keynesian Phillips curve as current inflation ($\pi_t$) depends on past inflation ($\pi_{t-1}$), expected future inflation ($E_t \pi_{t+1}$) and real marginal cost ($rmc_t$) as well as a shock term ($\varepsilon_t^{\pi}$). However, our empirical setting differs from the theoretical NKPC in important ways as our main aim is to explain the dynamics of the observed inflation in Turkey and pin down its determinants. For example, although the theory requires the use of the GDP deflator in the NKPC estimations, we use the consumer price inflation in our estimations as this is the relevant indicator of inflation in Turkey. Also, we define real marginal cost as a weighted sum of domestic ($rmc_t^d$) and foreign ($rmc_t^f$) components, which in turn depend not only on the current values of the relevant variables that make up these components, but also on their lagged values as suggested by the data.

$$rmc_t \equiv \zeta rmc_t^d + (1-\zeta) rmc_t^f. \tag{3}$$

Specifying a foreign component to the real marginal cost is in line with previous papers which derive NKPC for open economies that rely on intermediate imported inputs in production (Svensson, 2000 and McCallum and Nelson, 2000). In these papers, real marginal cost has a component that depends on import prices and the exchange rate. In similar vein, the foreign component of the real marginal cost given in equation (3) reflects costs related to imported inputs as well as the exchange rate:

[11] See Galí and Gertler (1999) for a derivation.

$$rmc_t^f = \mu_1 \pi_t^{M,d} + \mu_2 \pi_{t-1}^{M,d} + (1 - \mu_1 - \mu_2)\pi_{t-2}^{M,d}. \quad (4)$$

where $\pi_t^{M,d}$ denotes the quarterly change in import prices in domestic currency and is exogenous to the model. The lag structure imposed in equation (4) follows from Kara and Öğünç (2012), who find that it takes about three quarters for most of the exchange rate pass-through to the core CPI to be completed. Accordingly, we include two lagged values of the the quarterly change in import prices in domestic currency as well as its current value.

For the domestic component of the real marginal cost, $rmc_t^d$, we consider alternative specifications, which involve output gap or real unit labor cost, or both. The NKPC literature, which largely builds on advanced economies, commonly considers labor income share as a sole proxy for marginal production costs. However, some recent efforts, for instance Muto (2009), augment it with other non-labor costs such as material prices as well as measures of labor market frictions. In similar vein, Matthes and Wang (2012) emphasize that one proxy variable alone cannot capture the entire variation in marginal costs. It is in this respect that we include output gap and real unit labor cost together in some specifications.

In the baseline model, domestic real marginal costs only depend on the current and lagged values of output gap, $\tilde{y}_t$:

$$rmc_t^d = \omega_1 \tilde{y}_t + \omega_2 \tilde{y}_{t-1} + (1 - \omega_1 - \omega_2)\tilde{y}_{t-2}. \quad (5)$$

Output gap denotes the difference between actual and potential output and is determined outside the model. In the first alternative specification to equation (5), we utilize real unit labor cost instead of the output gap. Therefore, $rmc_t^d$ is written as equation (5').

$$rmc_t^d = \tau_1 \mathrm{ULC}_{t-1} + \tau_2 \mathrm{ULC}_{t-2} + \tau_3 \mathrm{ULC}_{t-3} + \tau_4 \mathrm{ULC}_{t-4} + \varepsilon_t^{cd}. \quad (5')$$

In another alternative, we let $rmc_t^d$ be a function of output gap as well as real unit labor cost and specify $rmc_t^d$ as in Equation (5''):

$$rmc_t^d = \Omega_1 \tilde{y}_t + \Omega_2 \mathrm{ULC}_{t-1} + \Omega_3 \mathrm{ULC}_{t-2} + \Omega_4 \mathrm{ULC}_{t-3} + \Omega_5 \mathrm{ULC}_{t-4} + \varepsilon_t^{cdu}. \quad (5'')$$

The lag structures in equations (5), (5') and (5'') reflect our prior that inflation is sluggish to adjust to indicators related to real economic activity and real unit labor cost. This prior relies on the findings of existing studies such as Alp et al. (2012) as well as simple statistical exercises carried out by the authors to examine the correlation between consumer price inflation (controlled for the effects of foreign costs) and current and lagged values of the output gap and real unit labor cost. We elaborate more on the specification of the lag structure when discussing the choice of priors in section 3.2.2.

### 3.2. Estimation Methodology

We use Bayesian inference which is becoming increasingly popular in the field of macroeconomics. This choice is due to the fact that the Bayesian approach outperforms generalized method of moments (GMM) and maximum likelihood in small samples (e.g. Rabanal and Rubio-Ramirez, 2005) which is an important concern for our study. In Bayesian inference; the likelihood function, which summarizes information in the data, is weighted by the priors that can be used to incorporate additional information into parameter estimation.[12] This mechanism adds some curvature to the posterior distribution, which prevents the posterior distribution to peak at strange points.

Let $\theta$ be the vector of parameters to be estimated and $Y_T$ be the observed data. The aim is to obtain the posterior density $p(\theta|Y_T)$. By using the Bayes theorem, the posterior density can be written as the following:

$$p(\theta|Y_T) = p(Y_T|\theta)p(\theta)/p(Y_T) \tag{6}$$

where $p(Y_T|\theta)$ is the likelihood function and $p(\theta)$ is the prior density. Here, the denominator of (6), $p(Y_T)$, is a constant normalizing the posterior density. Therefore, Bayesian estimation in essence focuses on the numerator of (6), explicitly written as the posterior Kernel $\kappa(\theta|Y_T)$:

$$p(\theta|Y_T) \propto p(Y_T|\theta)p(\theta) \equiv \kappa(\theta|Y_T) \tag{7}$$

Log posterior Kernel can be obtained as the sum of the two components. To estimate the first component, $p(Y_T|\theta)$, Bayesian estimation resorts to the Kalman filter. The second component, $p(\theta)$, is already known since it is set by the researcher. As the log posterior Kernel points out, if there is not much information coming from the prior then the likelihood function would dominate the Bayesian estimation.

As a final product, we need the posterior distribution of a given parameter. Since the posterior Kernel presented in (7) is nonlinear and highly complex to work with analytically, we make use of a numerical sampling method known as Metropolis Hastings (MH) to simulate the posterior distribution. To this end, we first obtain the mode of the posterior distribution by maximizing the log posterior Kernel. Then MH algorithm is applied by using the posterior mode as a starting point. If the chain is run often enough, the algorithm guarantees to converge to the target distribution. Once the posterior distribution of any parameter is approximated, then all posterior moments of interest might be obtained.

#### 3.2.1. Data

This study focuses on inflation dynamics after 2003 on account of the structural change experienced in the Turkish economy following the 2001 crisis. Therefore, the sample covers the period from 2003Q2 to 2012Q3. We measure inflation as the annualized quarterly

[12] For a more detailed information on Bayesian estimation, please refer to An and Schorfheide (2007).

change in the seasonally adjusted CPI excluding unprocessed food, alcoholic beverages and tobacco. Unprocessed food and tobacco prices exhibit short-term noisy movements and have the highest unexpected volatility among the CPI sub-components in Turkey. Hence, we prefer to exclude these items from the index and use a more refined measure, which accounts for about 84.3 percent of the headline CPI. Similarly, services inflation is computed as the annualized quarterly change in the seasonally adjusted services price index.

To model the foreign component of real marginal cost, we employ quarterly change in the import unit value index denominated in the Turkish lira. For the domestic component of the real marginal cost, we draw on output gap and real unit labor cost measured with alternative wage rates, i.e. total non-farm gross wage per employee and minimum wage rate. Since non-farm wage series are only available from 2005Q2, models incorporating labor costs cover the period 2005Q2-2012Q3.

The output gap employed in the baseline specification is a revised estimate of Alp et al. (2012) who derive output gap and its components jointly by using an estimated New Keynesian small open economy model. The authors decompose output gap into domestic demand gap, export gap and import gap, and model each component separately. For example, export gap is modeled as a function of foreign output gap and real exchange rate gap, whereas domestic demand gap is expressed as a function of its past and expected realizations as well as fluctuations in the real interest rate gap. The relationship between inflation and output gap is incorporated through the Phillips Curve. The output gap is treated as an unobservable to be estimated along with other parameters using Bayesian inference. There is a growing literature that applies similar methods to the estimation of output gap, Planas et al. (2008) and Benes et al. (2010) are a few to cite.

### 3.2.2. Priors

Choice of prior distributions relies on the conventional approach adopted in the literature, i.e. for parameters bounded between zero and unity, the beta distribution is used; whereas for those which are assumed to take positive values and have the possibility of being greater than one, the gamma distribution is chosen. Besides, the inverse gamma distribution is employed for the standard deviations of shocks.

It may also be useful to explain how we choose prior means for reduced form coefficients. We quantify prior means based on the findings of previous papers or by running a number of auxiliary regressions. For the coefficient on lagged inflation $(\gamma_b)$, we set the mean of the prior distribution to 0.6 based on the findings of Çebi (2011).[13] Alp et al. (2012) also take a value of 0.6 as a prior for $\gamma_b$, but end up with a higher posterior mean estimate for the core inflation indicator H (SCA-H), i.e. the CPI excluding energy, unprocessed food, alcoholic

[13] Çebi (2011) estimates the reduced form lagged inflation coefficient as 0.59 over the period 2002Q1-2009Q3 with Bayesian approach for GDP deflator and suggests that backward looking behavior remains predominant.

beverages, tobacco, and gold. This result can be attributed to the fact that services sector, which has a higher degree of inflation persistence[14], has a relatively larger share within the SCA-H compared to the CPI. Hence, we set the prior for $\gamma_b$ as 0.6.

The coefficient $\lambda$ is set to 0.25 based on the authors' own estimates relying on OLS and GMM regressions. We stay agnostic with respect to the share of domestic and foreign costs by setting the prior mean equal to 0.5 and adopting a higher standard deviation for this coefficient. The lag structure and coefficient values of the components of foreign costs are determined according to the findings of Kara and Öğünç (2012). For the models including real unit labor cost, we set prior means based on a number of regressions with a domestic cost measure proxy.[15] Also note that we drop insignificant lags of real unit labor costs depending on the initial regression results. More specifically, we drop $ULC_{t-1}$ and $ULC_{t-3}$ from equation (5') and $ULC_{t-1}$ from equation (5'') in our Bayesian estimations. Lastly, priors guiding the standard deviations of the shocks are based on an inverse gamma distribution typically centered on 0.02 apart from the shocks to inflation which have a mean of 0.025. The models are estimated with Dynare. Results are obtained with 100000 draws of which the first half is discarded.

## 4. Results

### 4.1. Baseline Model

Table 1 reports estimates for the baseline model for two different sample periods. The findings based on the period between 2003Q2 and 2012Q3 suggest that the estimate of $\gamma_b$ is 0.56 while that of $\gamma_f$ is 0.44. Hence, backward looking behavior is slightly dominant in shaping the inflation dynamics. However, the estimate of the degree of backwardness drops once we focus on more recent dynamics, i.e. considering the period that starts from 2005Q2.[16] In particular, the estimate of $\gamma_b$ is 0.49, while that of $\gamma_f$ is 0.51. For the same period, sum of squared errors (SSE) of our NKPC based inflation equation is 0.0088, half the one obtained using the first sample. To the extent that this provides a ground for giving more weight to the results of the more recent period between 2005Q2 and 2012Q3, we can conclude that forward looking behavior is at least as important as the backward looking behavior for consumer price inflation in Turkey.

[14] One approach to measure inflation inertia is to use the autoregression specification, where inertia or persistence is defined as the sum of the estimated autoregressive coefficients. Accordingly, the sum of first two autoregressive coefficients of services inflation for our sample period is 0.62 whereas that of core goods is 0.15. The sum for services inflation increases to 0.79 if the first four autoregressive coefficients are taken into account. On the other hand, this figure becomes even smaller for core goods inflation. These findings signal that the services inflation is the main source of inertia in the CPI inflation.

[15] To construct a domestic cost measure proxy, we simply estimate a consumer price inflation equation with lagged inflation and three lags of TL denominated import price inflation then use the residuals of this equation as a proxy.

[16] In a different context, Başkaya et al. (2012) show that inflation expectations are less sensitive to the lagged inflation compared to the inflation target and forecasts. They also report that the impact of lagged inflation on inflation expectations has decreased over time.

| Table 1. Parameter Estimates for the Baseline Model | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Sample Period: 2003Q2-2012Q3 | | Sample Period: 2005Q2-2012Q3 | |
| | Prior | | | Posterior | | Posterior | |
| **Parameter** | **Dist.** | **Mean** | **Std.** | **Mean** | **95% CI** | **Mean** | **95% CI** |
| $\gamma_b$ | Beta | 0.60 | 0.10 | 0.56 | (0.44, 0.70) | 0.49 | (0.40, 0.60) |
| $\gamma_f$ | | 0.40 | | 0.44 | | 0.51 | |
| $\lambda$ | Beta | 0.25 | 0.10 | 0.16 | (0.07, 0.23) | 0.17 | (0.10, 0.24) |
| $\sigma_{\varepsilon^\pi}$ | Inv.Gam | 0.025 | $\infty$ | 0.022 | (0.016, 0.027) | 0.019 | (0.014, 0.024) |
| **Cost Shares** | | | | | | | |
| $\zeta$ | Beta | 0.50 | 0.15 | 0.42 | (0.20, 0.64) | 0.36 | (0.14, 0.55) |
| $(1-\zeta)$ | | 0.50 | | 0.58 | | 0.64 | |
| **Foreign Cost Measure** | | | | | | | |
| $\mu_1$ | Beta | 0.50 | 0.20 | 0.68 | (0.43, 0.95) | 0.72 | (0.48, 0.96) |
| $\mu_2$ | Beta | 0.30 | 0.10 | 0.34 | (0.16, 0.50) | 0.33 | (0.17, 0.50) |
| $(1-\mu_1-\mu_2)$ | | 0.20 | | -0.02 | | -0.05 | |
| **Domestic Cost Measure** | | | | | | | |
| $\omega_1$ | Beta | 0.40 | 0.20 | 0.48 | (0.14, 0.82) | 0.51 | (0.17, 0.84) |
| $\omega_2$ | Beta | 0.40 | 0.20 | 0.44 | (0.11, 0.77) | 0.46 | (0.10, 0.78) |
| $(1-\omega_1-\omega_2)$ | | 0.20 | | 0.08 | | 0.03 | |
| **SSE** | | | | 0.0162 | | 0.0088 | |
| **Average acceptance rate per chain** | | | | 25% and 26% | | 27% | |

*Notes:* This table reports priors and estimates of the coefficients of Equations (2) through (5).

The coefficient on real marginal cost $\lambda$ is around 0.17 in both periods. The share of foreign real marginal cost, $1-\zeta$, is found to outweigh that of domestic real marginal cost. Besides, $1-\zeta$ gets quantitatively larger in the more recent period. An estimate of 0.64 for $1-\zeta$ is reasonably consistent with the high sensitivity of energy and core goods prices to external price pressures in Turkey. For instance, end-year inflation in 2011 was 10.45 percent, of which almost 5 percentage points was due to the rise in import prices and marked depreciation of the Turkish Lira (CBT, 2012). The estimates of $\mu_1$ and $\mu_2$ are statistically significant, suggesting that current and lagged values of domestic currency denominated import prices are relevant for explaining foreign real marginal costs. In particular, the contemporaneous effect, $\mu_1$, is estimated to be more pronounced. Output gap shows a similar lag structure. However, the estimates of $\omega_1$ and $\omega_2$ are close to each other, indicating that current output gap and its first lag are almost equally important.

Overall, the baseline model, which uses output gap as a proxy for domestic real marginal costs, does a good job in capturing consumer inflation dynamics in Turkey. As shown in Figure 3, fitted inflation tracks actual inflation quite closely (Figure 3). The most apparent deviation is in 2009 amid the global financial crisis, when the decline in output gap was much more pronounced than the decline in inflation. In this period, the estimated model underpredicts inflation for four consecutive periods. However, the fit of the model improves as the output gap starts to close later on. Overall, output gap based Phillips curve

augmented with an appropriate foreign cost component appears to deliver a good fit for the consumer inflation.[17]

**Figure 3: Actual versus Fitted Inflation (Baseline Model- Equations (2) through (5))**

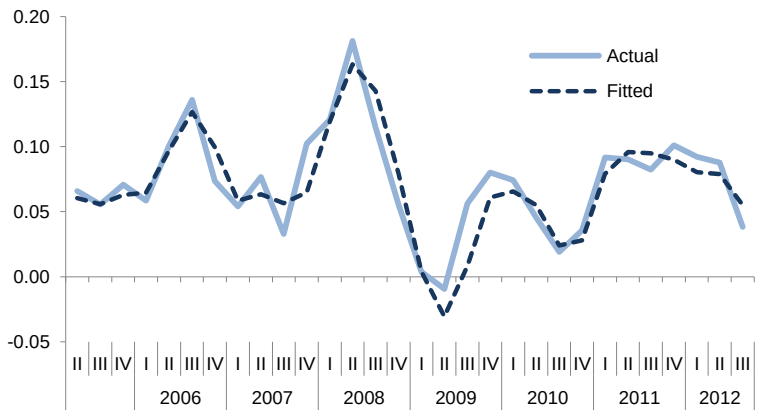



Figure 4 presents the estimated real marginal cost alongside the consumer inflation, showing an apparent co-movement between the two series. This signals that the proposed real marginal cost measure is successful in capturing inflation dynamics.[18] Figure 5 gives the breakdown of the estimated total cost measure into the domestic and foreign components, indicating that the turning points of inflation are largely determined by the foreign component even though both components contribute to inflation dynamics. Looking at the recent period, both foreign and domestic marginal cost pressures appear to be benign, driving the consumer inflation down.

**Figure 4: Real Marginal Cost (rmc) Estimate of the Baseline Model and Consumer Inflation**

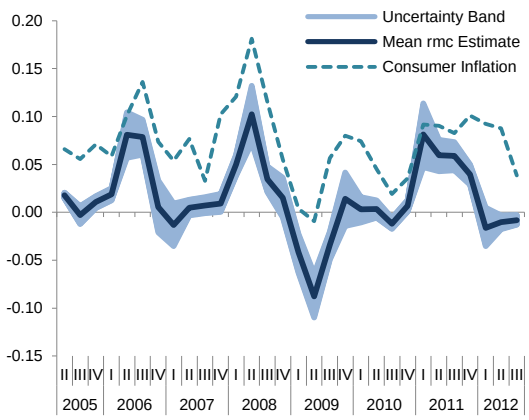
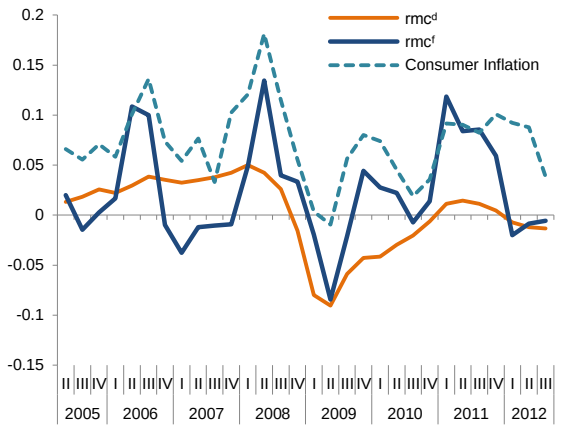



**Figure 5: Domestic and Foreign rmc Components in the Baseline Model**




[17] These results remain intact when alternative output gap estimates are considered for robustness. In order to conceive the effect of alternative output gap measures on the baseline model, the model is re-estimated by using two different output gap measures, specifically traditional HP filtered (1600) measure and a statistical filter-free output gap measure calculated by using directly observable survey-based gap indicators of business cycle (called observable output gap indicator, for further details see Coşar et al., 2012). Results point to relatively similar goodness of fit outcomes for different output gap estimates even though the baseline output gap measure presented in the tables produces the lowest SSE. Note that models employing HP filtered estimate and observable output gap indicator deliver SSE of 0.0090 and 0.0097, respectively.

[18] Bayesian method allows us to draw from the posterior distribution of each parameter so that we can calculate the uncertainty due to parameter estimates. In this respect, uncertainty band in the figures refers to the parameter uncertainty; it doesn't include any information as regards to model uncertainty. Mean estimate is the smoothed estimate of the relevant variable calculated by employing the mean of the parameter distributions.

## 4.2. Incorporating Labor Costs

We now turn to the estimation results of inflation equations incorporating real unit labor cost as a part of the domestic cost measure. Table 2 shows that employing $ULC^T$ instead of the output gap when modeling $rmc_t^d$ leads to a fall in the fit of the inflation equation. The SSE increases by 40 percent to 0.0123. Using $ULC^{MIN}$ slightly improves the estimation compared to using $ULC^T$ but the model still underperforms compared to the baseline case.[19] Therefore, traditional output gap based Phillips curve appears to perform better in empirical terms than real unit labor costs for Turkish CPI inflation.

Taking into account the fact that the output gap may be capturing different aspects of domestic real marginal costs such as non-labor costs; we also estimate a specification using output gap and real unit labor cost together to. In this case, the fit gets better compared to using only real unit labor costs, suggesting that output gap and real unit labor costs might have different information contents. However, as Table 2 presents, the SSE of the model, 0.0098, is still above the SSE of baseline model. It is interesting to observe that estimate of $\gamma_b$ is larger than $\gamma_f$ in models incorporating labor costs, implying a somewhat higher backward looking behavior in inflation. This difference might be due to the fact that the real unit labor cost is a less persistent series than the output gap (Figure 1). The higher persistence in output gap might be capturing some of the persistence in inflation dynamics in the baseline specification. Also, in the specifications utilizing the ULC, the parameter $\lambda$ is estimated to be slightly higher compared to the baseline. Estimates for the shares of domestic and foreign components seem to be robust across different specifications, around 0.4 and 0.6, respectively. Incorporating the ULC into the estimations also implies that the pass-through from domestic currency denominated import prices to inflation is somewhat faster compared to the baseline as the posterior mean for $\mu_1$ goes up to around 0.8 from around 0.7. However, relatively poor performances signal that these models may not be as good as the baseline model in capturing inflation dynamics. Therefore, we opt to attach a higher weight to the baseline estimates when interpreting the determinants of consumer price inflation in Turkey.

[19] We choose to discuss the results of the models with $ULC^T$ although $ULC^{MIN}$ produces slightly smaller sum of squared errors. This is due to the fact that total wage payments over total employment is considered to be a better representative of the wage rate in total economy compared to the minimum wage rate.

| Table 2. Parameter Estimates for Models Including Labor Costs | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample Period: 2005Q2-2012Q3 | | | | | | | |
| | | | | ULC$^{T}$ Based Model | | Output Gap and ULC$^{I}$ Based Model | |
| | Prior | | | Posterior | | Posterior | |
| **Parameter** | **Dist.** | **Mean** | **Std.** | **Mean** | **95% CI** | **Mean** | **95% CI** |
| $\gamma_b$ | Beta | 0.60 | 0.10 | 0.59 | (0.43, 0.72) | 0.54 | (0.41, 0.68) |
| $\gamma_f$ | | 0.40 | | 0.41 | | 0.46 | |
| $\lambda$ | Beta | 0.25 | 0.10 | 0.22 | (0.10, 0.34) | 0.23 | (0.11, 0.33) |
| $\sigma_{\varepsilon^{\pi}}$ | Inv.Gam | 0.025 | $\infty$ | 0.021 | (0.016, 0.028) | 0.019 | (0.014, 0.025) |
| **Cost Shares** | | | | | | | |
| $\zeta$ | Beta | 0.50 | 0.15 | 0.36 | (0.13, 0.58) | 0.41 | (0.17, 0.64) |
| $(1-\zeta)$ | | 0.50 | | 0.64 | | 0.59 | |
| **Foreign Cost Measure** | | | | | | | |
| $\mu_1$ | Beta | 0.50 | 0.20 | 0.76 | (0.55, 0.97) | 0.77 | (0.57, 0.97) |
| $\mu_2$ | Beta | 0.30 | 0.10 | 0.34 | (0.17, 0.51) | 0.35 | (0.17, 0.51) |
| $(1-\mu_1-\mu_2)$ | | 0.20 | | -0.10 | | -0.12 | |
| **Domestic Cost Measure** | | | | | | | |
| $\tau_2$ | Beta | 0.50 | 0.15 | 0.46 | (0.21, 0.70) | | |
| $\tau_4$ | | 0.50 | | 0.54 | | | |
| $\sigma_{\varepsilon^{cd}}$ | Inv.Gam | 0.02 | $\infty$ | 0.017 | (0.005, 0.033) | | |
| | | | | | | | |
| $\Omega_1$ | Beta | 0.50 | 0.15 | | | 0.52 | (0.29, 0.77) |
| $\Omega_3$ | Beta | 0.30 | 0.15 | | | 0.24 | (0.04, 0.44) |
| $\Omega_4$ | Beta | 0.25 | 0.10 | | | 0.23 | (0.08, 0.38) |
| $\Omega_5$ | Beta | 0.30 | 0.15 | | | 0.27 | (0.04, 0.48) |
| $\sigma_{\varepsilon^{cd}}$ | Inv.Gam | 0.02 | $\infty$ | | | 0.019 | (0.004, 0.038) |
| **SSE** | | | | 0.0123 | | 0.0098 | |
| **Average acceptance rate per chain** | | | | 27% | | 25% and 26% | |
| **SSE with ULC$^{MIN*}$** | | | | 0.0118 | | | |
| **SSE with ULC$^{MAN}$** | | | | 0.0122 | | | |

*Notes:* ULC based model reports the estimates of the parameters of Equations (2) through (4) and (5'). Output gap and ULC$^{T}$ based model presents the estimates of the parameters of the Equations (2) through (4) and (5''). *SSE of NKPC with ULC$^{MIN}$ (ULC$^{MAN}$) shows the sum of squared errors of the NKPC, where domestic real marginal costs are modeled with ULC$^{MIN}$ (ULC$^{MAN}$).

## 4.3. Modeling Services Inflation

Reaching the conclusion that including labor costs in $rmc_t^d$ does not help much to explain consumer price inflation better, we turn to estimating an equation for services inflation using the same setup. Baseline and alternative models are as described by equations (2) to (5'') with only differences being the definition of inflation, which is now services inflation instead of consumer price inflation; and the definition of real unit labor cost. We employ the ULC measures calculated either using the minimum wage series or total nonfarm wage payments per employee, both adjusted by services sector productivity.[20] Since services sector is intrinsically labor intensive, one could expect the ULC to be a relevant indicator in explaining the dynamics of services inflation.

[20] The ULC calculated using services sector wages move quite close to the ULC calculated using total nonfarm wages. These two measures yield similar results in the estimations for the services inflation.

| Table 3. Parameter Estimates for Models with Services Inflation | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample Period: 2005Q2-2012Q3 | | | | | | | |
| | | | | Output Gap Based Model | | Output Gap and $ULC^{MIN}$ Based Model | |
| | Prior | | | Posterior | | Posterior | |
| **Parameter** | **Dist.** | **Mean** | **Std.** | **Mean** | **95% CI** | **Mean** | **95% CI** |
| $\gamma_b$ | Beta | 0.60 | 0.10 | 0.66 | (0.53, 0.77) | 0.71 | (0.63, 0.80) |
| $\gamma_f$ | | 0.40 | | 0.34 | | 0.29 | |
| $\lambda$ | Beta | 0.25 | 0.10 | 0.13 | (0.07, 0.20) | 0.31 | (0.20, 0.42) |
| $\sigma_{\varepsilon^\pi}$ | Inv.Gam | 0.025 | $\infty$ | 0.013 | (0.01, 0.016) | 0.010 | (0.008, 0.013) |
| **Cost Shares** | | | | | | | |
| $\zeta$ | Beta | 0.70 | 0.10 | 0.64 | (0.48, 0.82) | 0.65 | (0.54, 0.77) |
| $(1-\zeta)$ | | 0.30 | | 0.36 | | 0.35 | |
| **Foreign Cost Measure** | | | | | | | |
| $\mu_1$ | Beta | 0.90 | 0.05 | 0.91 | (0.83, 0.98) | 0.91 | (0.85, 0.98) |
| $\mu_2$ | | 0.10 | | 0.09 | | 0.09 | |
| **Domestic Cost Measure** | | | | | | | |
| $\omega_1$ | Beta | 0.40 | 0.20 | 0.54 | (0.22, 0.88) | | |
| $\omega_2$ | Beta | 0.40 | 0.20 | 0.45 | (0.12, 0.78) | | |
| $(1-\omega_1-\omega_2)$ | | 0.20 | | 0.01 | | | |
| | | | | | | | |
| $\Omega_1$ | Beta | 0.60 | 0.15 | | | 0.68 | (0.49, 0.87) |
| $\Omega_3$ | Gamma | 0.80 | 0.15 | | | 0.76 | (0.53, 0.97) |
| $\Omega_5$ | Gamma | 1.50 | 0.20 | | | 1.49 | (1.19, 1.80) |
| $\sigma_{\varepsilon^{cdu}}$ | Inv.Gam | 0.02 | $\infty$ | | | 0.015 | (0.005, 0.025) |
| **SSE** | | | | 0.0044 | | 0.0021 | |
| **Average acceptance rate per chain** | | | | 26% | | 26% | |
| **SSE with output gap and $ULC^{T*}$** | | | | | | 0.0025 | |

*Notes:* This table shows the estimation results for the services inflation. Output gap based model reports the estimates of the parameters of Equations (2) through (5). Output gap and $ULC^{MIN}$ based model presents the estimates of the parameters of the Equations (2) through (4) and (5''). *SSE of NKPC with output gap and $ULC^T$ is the sum of squared errors of the NKPC, where domestic real marginal costs are modeled with both the output gap and $ULC^T$.

Table 3 presents the estimation results. When $rmc_t^d$ is modeled using solely the output gap measure, the SSE of the model is 0.0044. However, adding $ULC^{MIN}$ lowers the SSE by 52 percent to 0.0021.[21] If we were to use $ULC^T$ instead of $ULC^{MIN}$, there would still be improvement but to a lesser extent. This draws attention to the impact of the minimum wage on the prices of services. When the output gap and $ULC^{MIN}$ are both included, estimates of the coefficients on lagged versus future services inflation are 0.71 and 0.29, respectively. This suggests that the degree of backwardness is quantitatively larger in services compared to the broad inflation measure at hand. This finding is consistent with the observation that the price of services is the main source of the inertia in the CPI inflation.

The share of domestic real marginal costs, ζ, is estimated to be 0.65, implying that domestic costs have a larger impact on services inflation relative to foreign costs. This is just the opposite of what we find for the CPI, for which foreign costs dominate the total cost structure

[21] We also estimated the NKPC for services inflation using $ULC^{MIN}$ as the only proxy for $rmc_t^d$. Similar to the results discussed in Section 4.2, output gap and $ULC^{MIN}$ based model has a smaller sum of squared errors than $ULC^{MIN}$ based model, which has an SSE of 0.0035. Therefore, we only present the results of the former in Table 3.

of operating firms owing to the comparatively greater share of core goods which are quite sensitive to external prices.

A change in import prices is substantially and simultaneously reflected on foreign costs.[22] The estimate of the coefficient on the lag of import prices, $1 - \mu_1$, is only 0.09. To sum up, we can draw three main conclusions from these estimations: (i) backward looking behavior predominates the dynamics of services inflation, (ii) inflation in this sector is mostly driven by the domestic cost pressures as expected, and (iii) real unit labor cost developments, in particular those that are based on minimum wages, seem to have a significant impact on prices of services.

Figures 6 and 7 illustrate how services inflation is related to estimated total and domestic real marginal cost measures, respectively. Firstly, total marginal cost estimate moves quite close to its domestic counterpart as can be seen by comparing the blue lines in Figures 6 and 7. Secondly, services inflation is quite closely related to the real marginal cost estimate. The turning points in services inflation seem to follow those in the real marginal cost measures.

**Figure 6: rmc Estimate for Services Inflation**

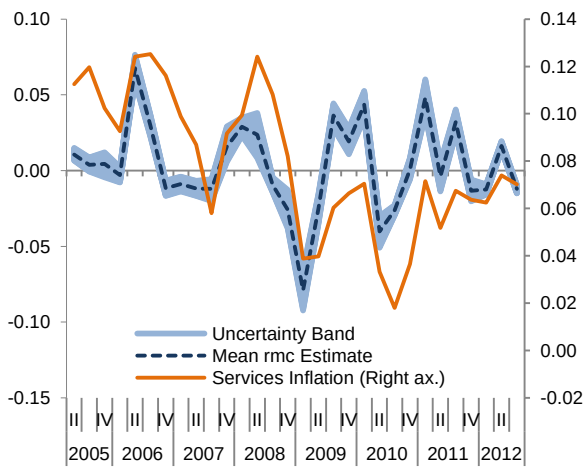
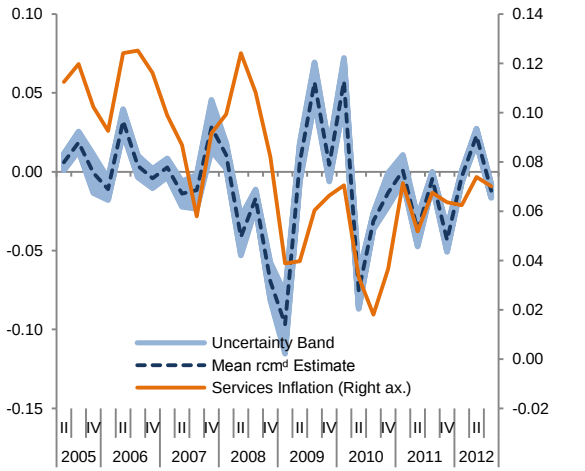



**Figure 7: Domestic rmc Estimate for Services Inflation**




## 5. Conclusion

We present Bayesian estimates of reduced form equations based on the hybrid NKPC to explain the dynamics of consumer price inflation in Turkey, focusing particularly on the domestic component of the real marginal cost. Furthermore, we provide estimates of real marginal cost which is treated as a latent variable. The baseline model, which uses current and lagged values of the output gap as a measure of the domestic real marginal cost does a better job at accounting for consumer price inflation in Turkey compared to alternative models that incorporate real unit labor costs. According to the baseline model estimated for the period between 2005Q2 and 2012Q3, backward and forward looking inflation terms are

[22] We also tested the impact of exchange rates apart from the import prices, yet the import prices have a better performance. This seems plausible given the existence of services related to import (oil) prices such as transportation.

found to be equally important for current inflation. This indicates a slight decline in the role of backward looking pricing behavior compared to the period that starts with 2003, which implies a gain in the credibility of the CBT after the adoption of the inflation targeting regime. However, given that the backward looking behavior in price setting is still strong, there is still room for improvement in the management of expectations.

The domestic component of the real marginal cost is estimated around 40 percent, while the remaining 60 percent is attributed to the foreign component. A policy implication that follows is that exchange rate stability is at least as important as managing aggregate demand for controlling inflation in Turkey.

When we use the same setup for services inflation, we find a more important role for the domestic component in total real marginal cost with a share of about 65 percent. In particular, the real unit labor cost measure calculated using the minimum wage appears to be closely related to services inflation. This seems plausible in the sense that services sector utilizes a higher share of labor input and a lower share of imported inputs compared to non-service sectors. This also points to the importance of aligning the minimum wage rate with changes in labor productivity to rein in services sector inflation. As a final point, the backward looking pricing behavior is found to be predominant, with a coefficient of 0.7 on the lagged inflation. Thus, stabilizing services inflation might be more costly in terms of economic activity, which highlights the importance of expectation management and further need for structural reforms so as to reduce the backward indexation in the price setting behavior.

For future work, it would be interesting to extend our real marginal cost measure to incorporate the financing costs of domestic firms following the literature that emphasizes the role of the working capital channel for emerging market countries.

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