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An Estimation of the Open Economy Hybrid New Keynesian Phillips Curve for Turkey

Türkiye İçin Açık Ekonomi Hibrit Yeni Keynesyen Phillips Eğrisi Tahmini

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Abstract

This study examines the inflation phenomenon employing monthly data set for the period 2002:01-2020:07 in Turkey. We separate the effects of dependency on imported intermediate goods and inputs in production using two different exchange rates. In this way, the direct effects arising from the USD / TL exchange rate and the indirect effects arising from the real effective exchange rate are revealed separately. In doing so, we also compare the sub-periods in which two separate trends occur in exchange rates. The results reveal that the real effective exchange rate has a more substantial effect. While this effect becomes more evident when the TL depreciates, it is seen that the USD / TL exchange rate is more determinant when the TL is stable. We find that both lagged and expected effects on inflation have a similar magnitude effect. This situation emphasizes the inertia and the importance of expectations in inflation. When the exchange rate increases, the effect of future expectations increases even more. The expected theoretical effect of the domestic output gap on inflation is statistically insignificant. According to the estimated model results, the effect of structural problems on inflation is relatively high and hampers price stability.

Jel Codes: *E31, E70, F41, E32, C36.*
Keywords: *Inflation, Expectations, Exchange Rate, Output Gap, Generalized Methods of Moments.*

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Öz

Bu çalışma Türkiye'de 2002:01-2020:07 dönemi için aylık veri seti kullanarak enflasyon olgusunu incelemektedir. Analizimizde üretimin ithal ara malları ve girdilere olan bağımlılığının fiyatlara olan etkileri iki farklı kur serisi kullanılarak incelenmektedir. Bu sayede USD/TL kurundan kaynaklanan doğrudan etkiler ile reel efektif döviz kurundan kaynaklanan dolaylı etkiler ayrı ayrı ortaya konmaktadır. Bunu yaparken de döviz kurlarında iki ayrı eğilimin meydana geldiği alt dönemler karşılaştırılmaktadır. Sonuçlar, enflasyon üzerinde reel efektif döviz kurunun daha önemli bir etkiye sahip olduğunu göstermektedir. TL değer kaybettiğinde bu etki daha belirgin hale gelirken, TL'nin durağan olduğu durumlarda USD/TL kurunun daha belirleyici olduğu görülmektedir. Enflasyon üzerinde hem gecikmeli hem de beklenen etkilerin benzer büyüklük etkisine sahiptir. Bu durum enflasyondaki ataleti ve beklentilerin önemini vurgulamaktadır. Döviz kuru yükseldiğinde geleceğe yönelik beklentilerin etkisi daha da artmaktadır. Modelde yurt içi çıktı açığının enflasyon üzerindeki beklenen teorik etkisi istatistiksel olarak önemsizdir. Tahmin edilen model sonuçlarına göre yapısal sorunların enflasyon üzerindeki etkisi görece yüksek olup, bu sorunlar fiyat istikrarını engellemektedir.

Jel Kodları: *E31, E70, F41, E32, C36.*
Anahtar Kelimeler: *Enflasyon, Beklentiler, Döviz Kuru, Çıktı Açığı, Genelleştirilmiş Momentler Yöntemi.*

1. Introduction

Under inflation targeting, it is essential to understand the effects of basic macroeconomic variables on inflation in terms of both speed and magnitude for central banks. For this reason, the issue of how inflation responds to shocks caused by principal determinants such as exchange rate, international prices, economic growth, inflation expectations, and wages is frequently discussed by researchers. When we focus on Turkey in particular, the exchange rate affects inflation through different channels, and these effects are examined frequently by researchers. The sensitivity of the exchange rate movements to capital flows in the Turkish economy is another well-known fact. In times of increased global growth and risk appetite, commodity prices and capital flows towards emerging economies also increase. Hence, economic activities in these economies are more substantial in these periods. Moreover, the effect of international prices on domestic production costs is implicit, as import prices and domestic growth increase together. Therefore, a positive correlation is observed between these two variables. Factors such as the inflation outlook, exchange rate volatility, current account deficit, and the direction and magnitude of changes in exchange rates may affect the exchange rate pass-through (ERPT) in developing countries, which are the small open economy. The magnitude of the ERPT differs in sub-groups of price indices (Mihaljek and Klau, 2008). For example, the ERPT may be lower in the services sector, in the prices of non-tradable goods or products which use relatively lower imported intermediate goods.

Changes in import prices affect final prices in two ways. Direct effects arise through imported final consumption goods included in the consumption basket (consumption channel). Thereby, the increases in import prices are reflected directly in the product price. Indirect effects arise from the cost of imported intermediate goods and energy used in the domestic

production (cost channel). Here, the increase in import price is reflected in prices in proportion to the share of imported input in total production cost. However, rates of price change resulting from the change in import price may differ from the expected due to factors such as market conditions, competitive environment, and it varies from country to country (Ertug et al., 2018). In Turkey, the share of imported intermediate goods in total import is about 73 percent, and consumer goods constitute about 12 percent. Changes in import prices affect domestic prices mostly through cost channel due to the Turkish economy's mentioned structural feature. Therefore, there is a close relationship between producer prices and import prices, and the ratio of imports in consumption and production determines the ERPT. Studies remark that the effect of exchange rate on prices has a broad sectoral spread. Atuk et al. (2014) and Ozmen and Sarikaya (2014) show that inflation in sub-groups of the CPI basket is largely determined by the import prices denominated in TL (Turkish Lira). Ozmen and Topaloglu (2017) conclude that the ERPT to inflation differs in CPI sub-groups, and the pass-through in the food group is significant.

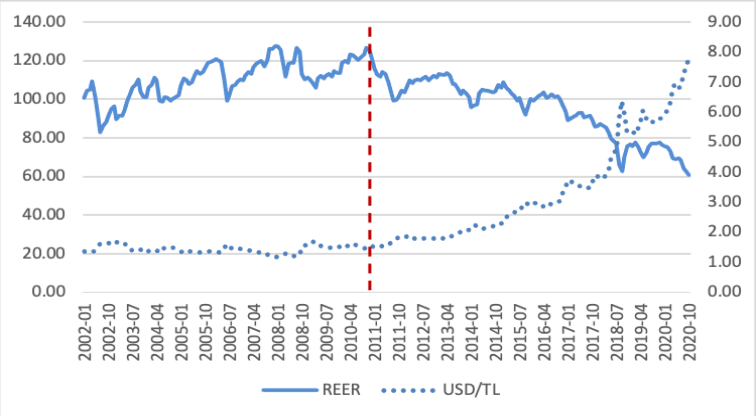
Exchange rates can also affect pricing behavior through inflation expectations. This effect is explained by the “indexation behavior” that emerges with the motive to hedge against inflation, as inflation and the exchange rate become mutually supportive. Kara et al. (2005) emphasize the high sensibility of inflation to the exchange rate, even in service sectors in which imported inputs rate is relatively low. Kara and Ogunç (2008), Damar (2010) and Yunculer (2011) underline that indexation behavior and ERPT weaken in the floating exchange rate regime. Also, a significant change is observed in the rate of transition from exchange rate to inflation. Before the floating exchange rate regime, exchange rate movements reflected much faster on prices, while the transition was slower and gradual in the following period. This indicates the importance of perceptions that exchange rate shocks are temporary or permanent. Moreover, Taylor (2000), Fuji and Bailliu (2004), Choudri and Hakura (2006) indicate that the relationship between inflation and the exchange rate weakens in a low inflation environment

Studies on the factors determining inflation expectations reveal that past inflation takes effect on inflation expectations in both developed and developing countries. Demertzis et al. (2010) state that the announced inflation targets in economies where the reliability of the central bank and price stability are established are relatively more determinant than the past inflation. Especially with the inflation targeting regime, it is observed that inflation expectations have decreased and at the same time, the relation of expectations with inflation realizations has diminished. In addition, targets emerge as an important factor that determines expectations in countries implementing inflation targeting regime (Mendonca, 2018). The fact that inflation rates in developing countries do not fall to the targeted levels may be due to many factors, especially the backward looking pricing behavior and the unreliability of the applied policy (Celasun et al., 2004). In these countries, inflation is known to be sticky due to the backward looking and indexing habit caused by chronic inflation, and this issue creates a significant problem for central banks (Dornbusch, 1982; Dornbusch and Werner, 1994). Baskaya et al. (2010) assert that the guidance of the inflation target on inflation expectations has increased and the role of past inflation rates in the formation of inflation expectations weakened.

The output gap is defined as the difference between current and potential output. It is used to measure inflationary effects from demand conditions. In case the current production level exceeds the potential, input (factor) costs also increase as the production capacity of the economy exceeds its productive level. This increases inflation, creating upward pressure on prices. However, inflation from the output gap is measured by the consumer price index. Moreover, increases in production costs differ for each sector. For instance, Atuk et al. (2014) prove that the reaction of most sub-items in the inflation basket to the output gap is insignificant. Likewise, Ozmen and Sarikaya (2014) state that the output gap affects the prices of services more than basic goods.

This study focuses on the determinants of inflation in Turkey under the inflation targeting regime with the floating exchange rate regime. In particular, we use USD / TL rate and real effective exchange rate to separate the effects of exchange rate movements on the cost and consumption channel. We also draw attention to the differentiation between the US dollar / TL rate and the real effective exchange rate (REER)[3] for two sub-periods (Figure 1). In order to determine the inflationary effects arising from the output gap, it is estimated with two different techniques by using monthy industrial production index. Thus, domestic and foreign inflationary effects of changes in marginal costs are compared. The effects of forward-looking and backward-looking inflation expectations on current inflation are also included in the analysis, and it is revealed how decisive inflation targets are on expectations.

Figure 1. The Course of Exchange Rates



Source:EDDS, CBRT

Organization of the article is as follows: Previous studies in the literature are summarized in the second part. In the third chapter, the theoretical model used in the analysis is developed. The data set and estimation method are discussed in the fourth chapter, and the estimation results are presented. The fifth section concludes the study including some policy recommendations.

[3] CPI-based real effective exchange rate is the weighted average of the ratio of the price level in Turkey to the price levels of 36 countries with foreign trade. It is calculated by Central Bank of Republic of Turkey for each month. Values above 100 indicate overvalued Turkish Lira, while values below 100 show depreciation in Turkish Lira.

2. Literatur Review

Many different studies investigated the cause of inflation in Turkey. We summarize some of them here to provide an empirical background to the model and analyzing method. Ogunç et al. (2018) examine inflation dynamics for the period 2005-2006 using impulse-response functions obtained from the BVAR model. The findings indicate that the effects of changes in import prices and exchange rates on inflation depend on the pass-through coefficients and the magnitude of the shocks. Besides, the exchange rate effect on inflation is more robust than import prices. Changes in both import prices and exchange rates are rapidly reflected in consumer prices. The effect of economic growth appears with a lag, but when compared to the import price and exchange ratepass-through effect, there is considerable forecast uncertainty. According to the results, import price pass-through occurs faster in the short term than the exchange rate, and most of the impact is completed in a relatively short period. These results indicate that the exchange rate affects pricing behavior beyond the cost channel. The exchange rate has a more deterministic role in the inflation process, as it is a hedging tool against inflation and its interaction with expectations.

Kara et al. (2017a) point out that one of the most significant contributions (with direct and indirect effects) to consumer inflation come from unprocessed food prices. The researchers compare the 2005-10 period (traditional inflation targeting) with the 2011-15 period (multi-purpose-multi-tool unconventional approach). The results indicate that the average inflation is the same in the two periods, but it varies considerably in terms of its components. The most striking point is that inflation is driven mostly by external factors in the first five years, while the contribution of fundamental macro factors such as output gap, exchange rate, and unit labor cost to inflation increases in the second five-year period. In the second period, wages and exchange rates, which are also related to inflation expectations, seem to be more effective. As global demand pressures on commodity prices are intense in the first half of the targeting period, the impact of external prices on consumer prices is strong. In the second half, this situation reverses with the slowdown trend of the global economy. The weakening of the global growth and risk appetite since 2013 positively affected inflation through commodity prices, while it became an upward pressure factor through capital flows and exchange rate channels.

Ertug et al. (2018) estimate VAR model to analyse ERPT effects. The model includes the imported input price index in US dollars, output gap, the US dollar / TL rate, and domestic producer price index. The model is estimated separately for each sector for January 2010 - December 2017 period with monthly data. According to the estimation results, the long-term import price and exchange rate pass-through coefficients differ significantly among the industrial sectors. While the import price pass-through coefficient can reach up to 70 percent, the exchange rate pass-through is between 5 percent and 107 percent. The sector with the highest pass-through coefficients is the manufacture of coke and refined petroleum products. This sector has also the highest use of imported inputs. The results state a positive relationship between the degree of differentiation of exchange rate and import price pass-through among the sectors and the sectors' imported input density. However, the ERPT is higher than the rate of imported input.

Kara et al. (2017b) remark that ERPT weakens in negative output gap, while it is stronger in positive output gap. It is seen that the pass-through effect is close to its historical averages (around 15 percent) when economic activity is near to its potential. On the other hand, cyclical fluctuations in economic activity may cause this effect to diverge. While the ERPT falls below 10 percent during periods of low output gap, it reaches 25 percent during periods of high output gap. The findings confirm that expectations are also effective in the pass-through process. In the case of strong depreciation in the local currency, the relationship between inflation and exchange rate is higher than the historical average, while this effect is much lower when expectations are positive.

Koca and Yilmaz (2018) explore the relationship between inflation and the output gap in Turkey with the reduced form Phillips curve models. They test nonlinear effects by adding the square of the output gap to these models and estimating the Phillips curve models for the period 2006Q4-2019Q3. The results show that the effect of economic activity on basic goods and services inflation could not be linear. The output gap has a remarkable impact on services inflation during periods of high economic activity and on core inflation during periods of weak economic activity.

In this study, we examine the period in which the inflation targeting regime was implemented both as a whole and in two separate sub-periods. The main distinction here is the path that will create two different sub-periods in the exchange rate. In this way, we can get the opportunity to compare the exchange rate effects on two different channels. We obtain the output gap using two different methods, and thus we estimate two different models. This enables us to analyze the effects of domestic cost pressures on inflation more clearly. We can also analyze the effects of lagged inflation and future inflation expectations with the GMM estimation method.

3. Theoritical Model

The New Keynesian Phillips Curve (hereafter NKPC) defines inflation as a function of expected future inflation and output gap. It has been developed with the contributions of different economists to the traditional Phillips curve proposed by Philips (1958). The NKPC claims that current inflation is affected by expected future inflation, and these expectations are rational. NKPC assumes that identical firms in monopolistic competition market produce differentiated products and market prices are set subject to similar constraints. Another assumption is that the price elasticity of demand for a product is fixed among firms. Calvo (1983) states that some of the firms keep their prices fixed with probability (θ), while others change their prices with probability ($1-\theta$). The objective of firms is to determine the optimum price level to maximize the discounted sum of their current and expected profits over time.

In the NKPC's reduced form equation in Gali and Gertler (1999), current inflation is determined by the expected future inflation and output gap or marginal cost. Mankiw (2001) and Woodford (2003) use a similar approach. According to the equation, the current domestic inflation rate is formulated by the expected future inflation and real economic activity:

$$\pi_{D,t} = \beta E_t \pi_{D,t+1} + \lambda \hat{y}_t \quad (1)$$

where $\hat{y}_t = y_t - \bar{y}_t$, $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$, and E_t indicates the expectation operator. Equation (1) is valued as the basic theoretical forward-looking NKPC. $\hat{y}$ refers the real marginal cost and calculates the deviation from the steady-state level (correlated with output gap). The slope coefficient λ, which shows the flexibility (sensitivity) of inflation to marginal cost, is a derivation of complex structural parameters. These parameters are the subjective discount factor β and the frequency of price adjustment θ. In the basic forward-looking NKPC, lagged inflation is assumed not to affect current inflation. But, empirical evidence points out the importance of persistency (lagged effects) in inflation. Therefore, a new NKPC curve has been developed that considers the effect of lagged and expected inflation on current inflation. In the hybrid NKPC, it is assumed that (1 - ω) of the firms are forward-looking. Accordingly, these firms set prices using all available information in the period *t* and consider the future marginal cost. The remaining of firms (ω) are backward-looking and determine their prices according to the general price level in the recent past. In this case, the hybrid NKPC is expressed in the following reduced form (Gali and Gertler, 1999):

$$\pi_{D,t} = \alpha_f \beta E_t \pi_{D,t+1} + \alpha_b \beta E_t \pi_{D,t-1} + \lambda \hat{y}_t \quad (2)$$

The slope coefficient in equation (2) is expressed as $\lambda = (1-\omega)(1-\theta)(1-\beta\theta)\phi^{-1}$ as in Abbas et al. (2016).[4] α_f and α_b are the weights of lagged and future inflation on current inflation, respectively. When all firms have a forward-looking behavior for determining their prices, the rate of backward-looking equals zero. In this case, the hybrid NKPC would also converge to the basic NKPC.

The basic forward-looking NKPC in equation (1) and the hybrid NKPC in equation (2) exclude external factors some like the openness of the economy and exchange rate dynamics.The effects of terms of trade and exchange rate shocks on inflation arise through the consumer price index. Gali and Monacelli's (2005) small open economy model explains the nominal price rigidity and thus incorporates the economy's interaction with the rest of the world into the model. In the model, domestic inflation is drived by future expected inflation and marginal cost:

$$\pi_{D,t} = \beta E_t \pi_{D,t+1} + \lambda \widehat{mc}_t \quad (3a)$$

The difference in the model from equation (1) is that consumer inflation (π_t) is used instead of domestic inflation ($\pi_{D,t}$). What determines the difference between the two inflation is the percentage change in terms of trade (tot_t):

$$\pi_t = \pi_{D,t} + \alpha \Delta tot_t \quad (3b)$$

Using Equations (3a) and (3b), the following equation is obtained, considering the change in terms of trade:

[4] Reduced form parameters in the equation are as follows: $\begin{bmatrix} \alpha_f = \beta\theta\phi^{-1} \\ \alpha_b = \omega\phi^{-1} \\ \phi = \theta + \omega[1-\theta(1-\beta)] \end{bmatrix}$

$$\pi_t = \beta E_t \pi_{t+1} + \lambda \widehat{mc}_t + \alpha[\Delta tot_t - \beta E_t \Delta tot_{t+1}] \quad (3c)$$

The real exchange rate (rer_t) is determined by terms of trade (tot_t) under the assumption of complete ERPT: $rer_t = (1-\alpha)tot_t$. Using this relationship, we can enhance the equation (3c) as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda \widehat{mc}_t + \frac{\alpha}{1-\alpha}[\Delta rer_t - \beta E_t \Delta rer_{t+1}] \quad (3d)$$

Domestic marginal cost is related to the output gap as follows: $\widehat{mc}_t = (\sigma_\alpha + \phi)\hat{y}_t$. By including this relation in equation (3d), we obtain:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa_\alpha \hat{y}_t + \frac{\alpha}{1-\alpha}[\Delta rer_t - \beta E_t \Delta rer_{t+1}] \quad (3e)$$

The slope coefficient $\kappa_\alpha = \lambda(\sigma_\alpha + \varphi)$ in equation (3e) is a function of the structural parameters as in Abbas et al. (2016)[5]. The α coefficient determines the slope of the PC as used Gali and Monacelli (2005) model. If $\alpha = 0$, the open economy NKPC curve in equation (3e) will transform into the closed economy and basic conceptual forward-looking NKPC curve in equation (1). Similar results are valid for $\sigma = \eta = \gamma = \omega = 1$. For this reason, the model in equation (3e) has been developed to understand inflation dynamics in an open economy. The difference between the current and expected change in the exchange rate plays an fundamental role in the model. It assumes that all imported goods are consumer goods. Therefore, the model does not include imported intermediate goods and inputs. According to Kurtner and Robinson (2010), imported intermediate goods prices affect firms' marginal cost. It then affects the desirable price level and inflation rate. Another assumption of the model is that the ERPT effect is complete. Campa and Goldberg (2005) found that this impact is incomplete in OECD countries.

An open economy NKPC curve that considers the impact of imported goods prices was developed by Balakrishnan and Lopes-Salido (2002). In the model, import prices affect the marginal costs of firms together with domestic goods. It is the openness of the economy that determines the weight of the two groups of goods:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda[(1-\alpha)\widehat{mc}_t + \alpha(p_t^m - p_t)] \quad (4.a)$$

Consumer price inflation π_t is specified by the marginal cost ($\widehat{mc}_t$) and the difference between imported goods prices (p_t^m) and domestic prices (p_t) As used in equation (1), the λ parameter is a function of price adjustment frequency (θ) and subjective discount factor (β). α is the openness index and shows the effect of real import prices on consumer inflation. The slope of the open economy NKPC curve $\lambda(1-\alpha)$ is the elasticity of inflation to marginal cost

[5] $\begin{bmatrix} \sigma_\alpha = \frac{\sigma}{(1-\alpha)+\alpha\omega} \\ \lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta} \\ \omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1) \end{bmatrix}$

where θ is the degree of price stckiness, β is the time discount factor, σ is the intertemporal substitution elasticity of consumption, α is the ratio of foreign goods in domestic consumption (as a proxy for openness), γ is the substitution among goods produced in foreign countries,and finally η is the substitution between domestic and foreign goods.

and is also drived by the share of imported goods prices. This situation adds an important feature to the model that is not present in previous models. If we apply the $\alpha = 0$ constraint here, we obtain the initial NKPC curve in equation (1). This also means that imported goods are final consumer goods and don't determine marginal cost. The hybrid NKPC model is expressed as below:

$$\pi_t = \alpha_f E_t \pi_{t+1} + \alpha_b \pi_{t-1} + \lambda[(1-\alpha)\widehat{mc}_t + \alpha(p_t^m - p_t)] \quad (4.b)$$

The reduced form parameters α_f and α_b are the weights given to expected and lagged inflation. Both parameters identify price stickiness θ, and discount factor β of the backward-looking price makers ω. The share of imported goods prices determines the elasticity of inflation to marginal cost $\lambda(1-\alpha)$. The higher the openness of the economy, the lower the effect of marginal cost on inflation. The open economy NKPC obtained in equation (4.b) is also related to all other versions. For $\alpha = 0$, we obtain the hybrid NKPC curve in equation (2). It means that imports are final consumer goods, and the ERPT effect is complete. For $\omega = 0$, there is a structure in which all firms determine their prices in a forward-looking behavior and $\alpha_b = 0$, $\alpha_f = \beta$. In this case, we obtain the equation (4.a). Therefore, $\alpha \neq 0$ and $\omega \neq 0$ constraints are valid for the open economy hybrid NKPC in equation (4.b).

We use the model in equation (4.b) in our analysis as noted in Abbas et al (2016). This model has a comparative advantage over other models in explaining inflation dynamics for Turkey. In the model, it is crucial that the prices of imported goods, used as inputs in production, affect firms' marginal costs and, subsequently, inflation. Domestic marginal cost effects are due to the output gap. In the case of a positive output gap, excess demand causes inflationary pressures arising from marginal costs. Gali and Gertler (1999), Woodford (2001), and Sbordone (2002) argue that marginal cost is a better proxy due to the problems that arise with the measurement of the output gap. There are many different determinants of the effects of past and future inflation in pricing decisions. In economies experiencing high inflation, above a certain level and regularly experienced inflation affects pricing decisions. The effect of forward-looking expectations changes depending on the current inflation and inflation targets.

4. Empirical Analysis

4.1. Data

This study employs the monthly data set for the period 2002:01-2020:07 to estimate the open economy hybrid NKPC curve. We exclude the effects of the Pandemic in our dataset. We obtained all data from the CBRT- EDDS, and time series were converted into logarithmic form. Inflation shows the rate of change in the consumer price index and the foreign markup effect is analyzed using two different data. While examining the effects of the indexation channel with the USD / TL rate (EXC), we consider the depreciation and appreciation of TL against other currencies with the CPI-based real effective exchange rate (RER). For that purpose, we use the deviation of both data from the steady-state. The industrial production index measures the output gap and captures the domestic markup effect. However, measuring the output gap is essential, and there are different techniques developed for this measurement. We obtain two different output gap data using the HP filter and Kalman filter methods. Figure 2 and Table 1 present descriptive information about the dataset.

Figure 2. Time Series Plots of Variables

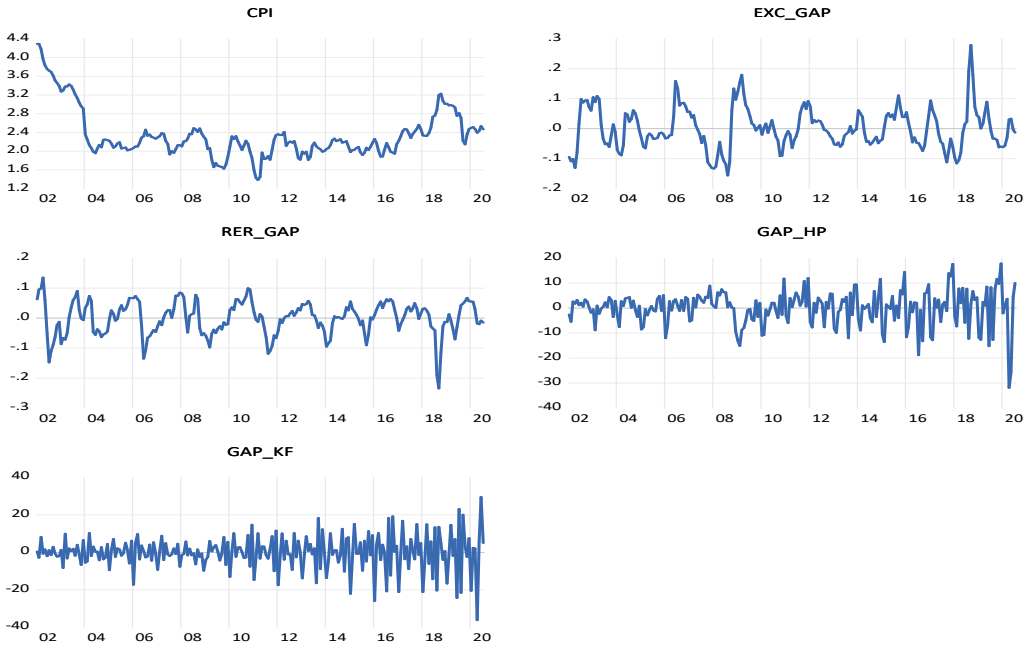


Table 1. Time Series Properties of Variables

	LCPI	EXC_GAP	RER_GAP	GAP_HP	GAP_KF
Mean	2.342334	1.57E-13	7.16E-13	0.013421	1.52E-09
Median	2.214846	-0.008723	0.004344	0.926722	-0.061052
Maximum	4.292649	0.279692	0.135091	17.82273	29.51895
Minimum	1.383791	-0.156203	-0.234723	-31.93008	-36.16105
Std. Dev.	0.514963	0.068006	0.054553	6.867849	8.889270
Skewness	1.561384	0.533951	-0.731794	-0.849939	-0.472662
Kurtosis	5.602643	3.821061	4.289911	5.375227	4.909429
Jarque-Bera	153.5487	16.86027	35.36371	79.26986	42.18006
Probability	0.000000	0.000218	0.000000	0.000000	0.000000
Sum	522.3406	3.50E-11	1.60E-10	2.992818	3.40E-07
Sum Sq. Dev.	58.87138	1.026714	0.660679	10471.15	17542.24
Observations	223	223	223	223	223

The first technique used to estimate the output gap is the HP-filter method developed by Hodrick and Prescott (1977). Like other statistical techniques, this method is not based on economic theory and is easy to use. For this reason, it has become almost standard to obtain the output gap in the literature. In the HP-filter method, the relevant series (here, output y_t) is decomposed into two components: Permanent-trend component (k_t) and temporary-cyclical component (g_t):

$$y_t = k_t + g_t$$

In the HP estimation process, these two components are assumed to be completely independent of each other, and the permanent (trend) component is estimated at the first stage. In order to predict the k_t component, a penalty function derived from the change in the sum of squares of the temporary component and the second difference of the permanent component must be minimized:

$$\min_{\{c_t\}_{t=1}^{T}} \sum_{t=1}^{T} [(y_t - k_t)^2 + \lambda [(k_{t+1} - k_t) - (k_t - k_{t-1})]^2]$$

Here λ refers to the ratio of the variance of the temporary component to the variance of the permanent component. It is also a penalty parameter that affects the smoothness of the estimated permanent component. Therefore, the λ parameter has a significant effect on this filter. As a result of the increase in λ, a smoother permanent component and a more volatile temporary component are obtained. It is assumed that these permanent and temporary components are unrelated, and the temporary component is white noise. Hodrik and Prescott (1980) suggested some λ values depending on the frequency of the data used. For monthly data, it is λ=14400. Cerra and Saxena (2000) state that using mechanically calculated correction parameter values often leads to pseudo cycles. Another main criticism of the HP filter is the end-of-sample deviation. Because this filter has a symmetrical structure, it does not cause bias in the sample's minimum and maximum points. However, this is related to the infinite sampling feature of the filter. In other words, the filter is symmetrical only if there are an infinite number of observations. The finite sample takes an asymmetric form due to the HP filter's weakness in determining the trend in recent data. It is called the end-of-sample deviation.

The second method to estimate the output gap is the unobservable components approach. This method gives much more accurate results compared to mechanical filtering methods. In this method, observed series are used to obtain unobservable series. Often there is a hidden relationship between the unobservable series and observable series. Therefore, unobservable series can be estimated using the observed series. In this method, firstly, a dynamic equation system that defines the relationships between data is created. Here observed variables are defined as a function of unobservable variables. At the same time, the autoregressive processes and transition equations of these variables are defined. This dynamic set of relationships is called "state-space form". Kalman's (1960, 1963) algorithm is used to obtain unobservable components in the dynamic equation system expressed in state-space form. The Kalman algorithm iteratively predicts the state-space model's state vector and creates new information by comparing the forecast and observation at each step. With this new information created, the forecast can be updated at every step. In this way, the average of the prediction errors' squares is minimized (Kalman, 1960; Kalman & Bucy, 1961).

We can define the linear state space model as a system of equations:

Signal - observation equation : $y_t = H_t\beta_t + A_tZ_t + \varepsilon_t$

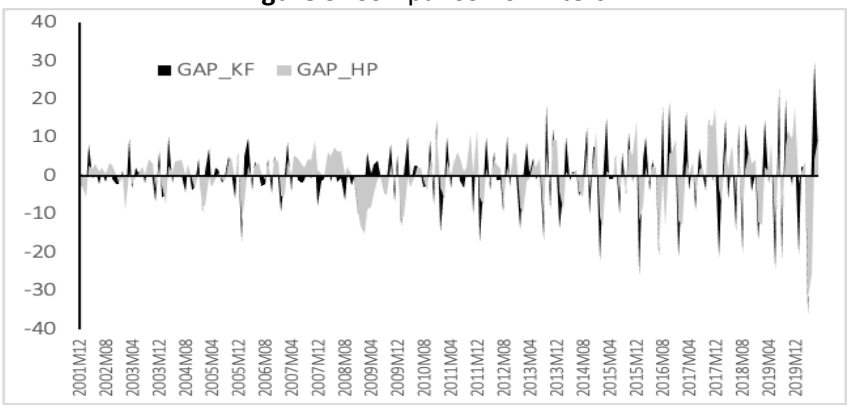
State - transition equation : $\beta_t = \mu_t + F_t\beta_{t-1} + S_t\nu_t$

Here y_t (n x 1) dimensional observable variables vector, H_t (n x m) dimensional matrix, Z_t (n x k) dimensional exogenous variables matrix, β_t (m x 1) dimensional unobservable state

variables vector, A_t (k x n) dimensional parameters matrix and εt is the vector of error terms. The error terms traditionally have the properties of $E(\varepsilon_t) = 0$ and $var(\varepsilon_t) = R_t$, representing the matrix of dimension R_t (n x n). According to state-transition equation, unobservable state variables (t) are created by the first-order Markov process. Here, F_t (m x m) dimensional matrix, μ_t (m x 1) dimensional vector, S_t (m x g) dimensional matrix and v_t (g x 1) dimensional error vector without serial correlation. The error terms have traditional properties $E(v_t) = 0$ and $var(v_t) = Q_t$ and Q_t is matrix with a dimension of (g x g).

Our study uses the monthly industrial production index data to measure the output gap. We prefer this in order to see the domestic markup effects more clearly and correctly. Figure 3 compares the estimations of output gap by the Kalman and HP filters (GAP_KF and GAP_HP).

Figure 3. Comparison of Filters



Source: Authors' calculations

Table 2 tabulates the unit root test results of the series used in the estimation process. According to the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test results, all series we use in model estimation are stationary at their log levels; that is, they represent I(0) charecteristic.

Table 2. Unit Root Test Results

Variables	ADF	PP
EXC	-6.118*	-4.936*
RER	-6.280*	-4.870*
GAP_HP	-3.836*	-12.41*
GAP_KF	-5.645*	-59.36*
* one-sided p values at 1% level		

4.2. Estimation Method

In the model, current inflation is affected by inflation expectations, and these expectations are rational. The rational expectations theory assume that economic agents behave by knowing the structure of the model when forming their expectations. Hereunder, they form their inflation expectation in *t+1* period using all the information in period *t*: $E_t\pi_{t+1} =$

$E\ (\pi_{t+1}/\Xi_t)$. Here we define the information set they used in the period t with Θ_t. There may be an error between expectations and actual inflation:

$$\pi_{t+1} = E\pi_{t+1} + \epsilon_{t+1}$$

However, the average of expectations generated using the entire set of information does not follow a specific trend (unbiased), the variance of prediction errors is constant, and there is no correlation between estimation errors of different periods:

$$E(\epsilon_{t+1}/\Xi_t) = 0\ ; E(\epsilon_{t+1}^2/\Xi_t) = \sigma_\epsilon^2\ \ ; E(\epsilon_{t+1}\epsilon_{t+1+l}/\Xi_t) \quad \forall\, l$$

Therefore, equation (4.b) can be rewritten as follows:

$$\pi_t = \alpha_b\pi_{t-1} + \alpha_f E_t\pi_{t+1} + \lambda[(1-\alpha)\hat{y}_t + \alpha(p_t^m - p_t)] + \upsilon_{\pi,t} \qquad (5)$$

The correlation between $\upsilon_{\pi,t}$ and π_{t+1} in Equation (5) causes an endonegeity problem in the model. The relationship between inflation and the real effective exchange rate causes the same problem because there is bidirectional causality between the two variables. Expected changes in both variables affected by other macroeconomic variables (for instance, the effect of a change in policy rate) also cause the same problem. The relationship between inflation and its main determinants may not be unidirectional. In Turkey, it is possible to mention a vicous circle in which past inflation affects wages and in turn high wages create an upward pressure on inflation. A similar interaction is observed between inflation and the exchange rate from time to time (Ogunc et al., 2018). Therefore, it is necessary to consider the bidirectional causality between these variables.

Two methods are used in the literature to eliminate the potential endogeneity problem that may arise during the estimation process: Generalized Methods of Moments (GMM) proposed by Hansen (1982) and Two-Stage Least Squares (TSLS) developed by Cumby et al. (1983). However, there are some advantages of the GMM estimation method over TSLS. In the GMM estimation method, we can use instrumental variables and the OLS method together. Besides, the variance and autocorrelation problem in error terms can be corrected by using the GMM method. For this reason, we will prefer the GMM method. One of the critical steps of the GMM method is to determine the appropriate instrumental variables and lag length. The instrument variables determined here should not be correlated with the predicted future value of inflation (π_{t+1}) and the error term. For this reason, it should be checked that the lagged values of inflation and other explanatory variables are determined correctly and that they do not represent any correlation with the error term. Gali and Gertler (1999) state that in the absence of correlation, error terms are distributed independently and identicaly.

In the GMM method, two criteria must be considered to determine the number of instrument variables. First, the number of instrument variables must be sufficient to capture the movements in the relevant variable. Second, it is not preferable to have a large number of instrument variables. In this case, equation can be overfitted and may give biased results. Stock and Yogo (2005) state that in case there are more than two instrument variables, critical values should be greater than 10. According to Stock and Watson (2007), the F-statistic greater than 10 indicates that there are no weak instrument variables in the model. However, we can check whether the instruments meet the orthogonality conditions using the difference-in-

Sargan test (the C test). We test the issue of over-idendification of the model by looking at the J-statistic and the corresponding p-value as used in Ali (2013).

4.3. Empirical Findings

We estimate the reduced form in equation (5) for the period 2002:01-2020:07 and two sub-periods. Two different output gaps are used to measure the domestic markup caused by changes in industrial production. For the output gap, two different models are used for each period employing the values obtained using two different filters. In addition, we examine the markup effects resulting from changes in imported input prices separately for the nominal and real effective exchange rate. In this way, we compare the effects of the USD / TL rate and the real effective exchange rate. It allows us to compare direct pricing and markup pricing decisions. In Turkey, the USD / TL rate has a significant impact on pricing decisions. On the other hand, real effective exchange rate also shows the effect of imported goods and inputs first on the production and then on the price level. Table 3 presents all the estimation results. R^2 and J-statistic values show that the model using the Kalman filter's output gap has better estimation performance. However, we should note that there are no significant differences between the coefficients obtained in all prediction models. We should also note that the output gap does not have a significant effect on consumer inflation for all models. This result is similar to Ogunc et al. (2018) mentioned above. Bari and Adalı (2020) also state that the output gap does not have short and long-term effects on inflation.

We interpret the coefficients of the prediction results (GAP_{KF} column) using the Kalman filter. The estimation results reveal that forward-looking inflation expectations have an impact on current inflation. It emphasizes that expectations are important in pricing decisions. A 1% increase in expected inflation has an effect of approximately 0.55% on current inflation. It is noteworthy that this effect is higher (from 0.57% to 0.60%) when the TL depreciates and is similar to other studies' results. As stated in Kara et al. (2017a) and Kara et al. (2017b), inflation expectations also increase during periods of the rise in exchange rates. As in Bulut (2018), it is confirmed that the USD / TL exchange rate is an effective factor on inflation expectations.

However, the lagged effects of inflation also have a very high impact. This effect is lower in the period of depreciation in TL. It is again explained by the increase in the effect of exchange rates and expectations on pricing decisions. We use instrument variables with 4 lagged periods (months) to analyze these effects. Test results confirm that all other lags have been appropriately set except for the first lag (Appendix A).

Table 3. Estimation Results

Parameters	**GAP_{KF}**		**GAP_{HP}**		**GAP_{KF}**		**GAP_{HP}**	
	Coeffi-cient	Std. dev.	Coeffi-cient	Std. dev.	Coeffi-cient	Std. dev.	Coeffi-cient	Std. dev.
2002M01-2020M07								
CPI (+1)	0.548 *	0.044	0.538 *	0.044	0.553 *	0.043	0.537 *	0.045
CPI (-1)	0.451 *	0.044	0.462 *	0.043	0.446*	0.043	0.463 *	0.045
REER	-0.152 **	0.069	-0.131***	0.081	-	-	-	-
EXC	-	-	-	-	0.119 **	0.052	0.073**	0.081
GAP	0.000	0.000	-0.002	0.002	0.000	0.000	-0.002	0.002

R^2	0.9737		0.9727		0.9739		0.9729	
J-stat. *(Prob.)*	4.7854 (0.68)		3.700 (0.81)		5.2467 (0.62)		4.1358 (0.76)	
2002M01-2011M12								
CPI (+1)	0.573 *	0.055	0.546 *	0.043	0.577 *	0.052	0.551 *	0.043
CPI (-1)	0.428 *	0.053	0.455 *	0.042	0.425 *	0.051	0.450 *	0.042
REER	- 0.005 **	0.083	0.012 **	0.102	-	-	-	-
EXC	-	-	-	-	0.047 **	0.061	-0.010 **	0.095
GAP	0.002	0.002	0.001	0.002	0.001	0.001	-0.001	0.001
R^2	0.9845		0.9845		0.9845		0.9845	
J-stat. *(Prob.)*	7.8291 (0.35)		7.3670 (0.39)		7.3870 (0.39)		7.3477 (0.39)	
2011M01-2020M07								
CPI (+1)	0.599 *	0.083	0.606 *	0.089	0.576 *	0.083	0.589 *	0.085
CPI (-1)	0.399 *	0.083	0.392 *	0.089	0.423 *	0.084	0.409 *	0.085
REER	-0.249 **	0.125	-0.249 **	0.129	-	-	-	-
EXC	-	-	-	-	0.181 **	0.079	0.182 **	0.089
GAP	0.000	0.000	-0.001	0.002	0.000	0.000	-0.000	0.002
R^2	0.9485		0.9479		0.9511		0.9473	
J-stat. *(Prob.)*	3.2143 (0.86)		3.0927 (0.87)		3.9086 (0.79)		3.0602 (0.87)	
*,** and *** indicate significancy at 1%, 5%, and 10%, respectively.								

When we consider the overall forecast period, the real effective exchange rate has a more pronounced effect on inflation than the USD/TL exchange rate. While 1% depreciation in the real exchange rate has an effect of 0.15% on inflation, a 1% increase in USD / TL rate is approximately 0.12%. When we examine the sub-periods, an exciting result emerges: While the effect of the nominal exchange rate is more dominant (approximately 0.047% to 0.005%) in the first period, and the real effective exchange rate is more effective (approximately 0.25% to 0.18%) in the second period. We set the instrument variables for both exchange rate variables, including lags of three periods, and test results confirm that appropriate lags are used (Appendix A).

5. Conclusion

During the inflation targeting regime, the factors determining inflation differ depending on the dynamics emerging in different sub-periods. The exchange rate effect, which emerges as a result of the structural economic problems, has a significant effect on inflation. Due to the dependency of production structure on imported intermediate goods and input, exchange rate increases indirectly cause price increases. However, the direct exchange rate effect on imported consumption goods is also quite effective. Exchange rate movements have a substantial effect on pricing behavior over forward-looking expectations.

After the successful first years (2002-2005) in the inflation targeting regime, actual inflation rates have been increasingly higher than the targets in the years to date. This situation caused the reliability gap to increase and, consequently, the effect of targets on expectations to decrease. Although we compare the effect of the output gap in the model estimation using two different measurement methods, it does not significantly affect inflation. This fact may be clarified as follows: the expected inflationary effect in the case of a positive output gap is suppressed by the low-capacity production level and high unemployment. Findings of the estimated models also support these views.

The effects of USD / TL and the real effective exchange rate differ when analyzed for two separate periods. In the period when the USD / TL rate remained stable, and the real effective exchange rate increased, the USD / TL rate is dominant. However, it is observed that the real effective exchange rate is more dominant in the period when the USD / TL rate rises and the real effective exchange rate decreases (when the value of TL sharply depreciates).

Both past inflation and expected inflation have forcible effects on current inflation. The effect of experienced high inflation emphasizes that inflation stickiness (inertia) is substantial. It means that the guidance of inflation targets disappears. It draws attention to the fact that monetary policy has failed to make economic agents believe in inflation targets. In the rise in the exchange rate, the effect of expectations on inflation also increases. This situation leads to the existence of the indexation channel. Therefore, it is vital to develop a structure that will eliminate indexation behavior.

There is an essential structural obstacle for the Central Bank to achieve its price stability objective. Exchange rate movements stemming from the production structure and the current account deficit (savings deficit) considerably affect inflation through different channels. The solution to this problem is beyond the control of the monetary policy or the Central Bank. Nevertheless, it has a significant restriction on monetary policy. The effectiveness of monetary policy can be increased, and price stability can be achieved with a consistent monetary policy implemented by a highly creditable central bank. On the other hand, it is also essential to resolve structural problems that restrict monetary policy effectiveness and cause exchange rate shocks.

Appendix A. Instrument orthogonality C-test

	2002M01-2020M07		2002M01-2010M12		2011M01-2020M07	
Test instrument	GAP_{KF}	GAP_{HP}	GAP_{KF}	GAP_{HP}	GAP_{KF}	GAP_{HP}
CPI_{t-1}	5.555 (0.01)	6.215 (0.01)	0.234 (0.62)	0.135 (0.71)	7.332 (0.00)	7.526 (0.00)
CPI_{t-2}	0.001 (0.96)	2.414 (0.12)	1.070 (0.30)	1.171 (0.27)	5.425 (0.02)	0.220 (0.63)
CPI_{t-3}	1.033 (0.30)	0.931 (0.33)	0.806 (0.36)	0.415 (0.51)	0.511 (0.47)	0.093 (0.75)
CPI_{t-4}	4.518 (0.03)	3.132 (0.07)	2.437 (0.11)	1.799 (0.17)	0.820 (0.36)	0.078 (0.37)
EXC_{t-1}	0.783 (0.37)	0.423 (0.51)	0.035 (0.85)	0.029 (0.86)	1.237 (0.26)	0.586 (0.44)
EXC_{t-2}	0.813 (0.36)	0.311 (0.57)	0.006 (0.93)	0.029 (0.86)	1.63 (0.20)	0.652 (0.42)
EXC_{t-3}	0.325 (0.56)	0.139 (0.70)	0.246 (0.61)	0.079 (0.77)	1.661 (0.20)	0.906 (0.34)
$REER_{t-1}$	0.221 (0.63)	0.005 (0.93)	0.000 (0.97)	0.015 (0.90)	0.860 (0.35)	0.269 (0.60)
$REER_{t-2}$	0.130 (0.71)	0.000 (0.97)	0.051 (0.82)	0.058 (0.80)	2.327 (0.12)	0.706 (0.40)
$REER_{t-3}$	0.014 (0.90)	0.014 (0.90)	0.041 (0.83)	0.176 (0.67)	1.148 (0.28)	1.140 (0.28)
GAP_{t-1}	0.911 (0.33)	0.102 (0.74)	0.232 (0.62)	0.810 (0.36)	0.770 (0.38)	0.092 (0.76)
GAP_{t-2}	0.328 (0.56)	0.062 (0.80)	0.273 (0.60)	0.866 (0.35)	0.177 (0.67)	2.040 (0.99)
GAP_{t-3}	0.038 (0.84)	0.015 (0.90)	0.191 (0.66)	0.000 (0.97)	0.002 (0.95)	0.027 (0.86)
The null hypothesis is that the specified instrumental variable is proper. Probability values are presented in ( ).						

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