NEW KEYNESIAN PHILLIPS CURVE ESTIMATION: A MONTHLY ANALYSIS FOR TURKEY

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Approval of the Institute of Social Sciences

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ABSTRACT

NEW KEYNESIAN PHILLIPS CURVE ESTIMATION:
A MONTHLY ANALYSIS FOR TURKEY

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Understanding the characteristics of inflation dynamics is important since the appropriate course of monetary policy depends on the nature of inflation dynamics. New Keynesian Phillips Curve (NKPC) enables to know about the price dynamics in an economy. In this study our aim is to estimate the NKPC for Turkey, so the average price stickiness duration for Turkey by using the methodology of Ahrens and Sacht (2014). We use monthly data for Turkey over the period January 1999 and March 2016. We estimate the model by using Generalized Methods of Moments (GMM) analysis with different instrument sets including change in inflation which is calculated by consumer price index, change in foreign country interest rate, and change in exchange rate. We use the sample data taken from IFS of IMF, OECD and CBRT. We also need some parameters for the estimation of the model, and we take them from some research papers and articles. The results show that the Calvo price stickiness parameter for Turkey within the given period is in the range (0.73-0.80), which means the average price stickiness duration is approximately 3-5 months. Therefore, we conclude that the average price changes occur once in every 3-5 months in Turkey for given parameters. This study differs from the general literature of NKPC estimation for Turkey due to the coverage of the data period, the frequency of data and the type of methodology which is applied.

Keywords: New Keynesian Phillips Curve (NKPC), Price Stickiness, GMM, Calvo parameter

ÖZET

YENİ KEYNESYEN PHİLLİPS EĞRİSİ TAHMİNİ:
TÜRKİYE İÇİN AYLIK VERİLER İLE ANALİZ

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Kısa vadeli enflasyon dinamiklerinin niteliğini anlamak uygun para politikasının buna bağlı olmasından dolayı önemlidir. Yeni Keynesyen Phillips Eğrisi (NKPC) bir ekonomideki fiyat hareketleri konusunda bilgi edinmemizi sağlamaktadır. Bu çalışmada Ahrens & Sacht (2014) metodolojisi kullanılarak Türkiye için Yeni Keynesyen Phillips Eğrisi tahmini yapılması ve ortalama fiyat katılığı süresinin bulunması amaçlanmıştır. Kullanılan veriler aylık veriler olup, Türkiye için Ocak-1999 ve Mart-2016 arasındaki dönemi kapsamaktadır. Çalışmada Genelleştirilmiş Momentler Yöntemi (GMM) kullanılmış olup araç değişkenler ise enflasyon, yabancı ülke faiz oranı ve döviz kurundaki değişmelerden oluşmaktadır. Çalışmada kullanılan veriler IFS, OECD, CBRT gibi ulusal ve uluslararası kurum ve kuruluşların sitelerinden alınmıştır. Çalışmada gereken bazı parametrelerin değerini belirlemek için literatürdeki diğer çalışmalardan yararlanılmıştır. Çalışma sonucunda Türkiye için ele alınan dönemdeki fiyat katılığı parametresi (0.73-0.80) aralığında bulunmuş, Türkiye'deki ortalama fiyat katılığı süresi 3-5 ay olarak hesaplanmıştır. Sonuç olarak, kullanılan veri seti ve parametre değerleri sonuçları, ortalama fiyat değişikliklerinin neredeyse 3-5 ayda bir gerçekleştiğini göstermektedir. Çalışma; veri setinin aralığı, uygulanan metodoloji, ve ülkemize ait literatürdeki çeyreklik verilerle yapılmış birçok çalışmanın aksine tahminde aylık veriler kullanılması bakımından farklılık içermektedir.

Anahtar Kelimeler: Yeni Keynesyen Phillips Eğrisi, GMM, Fiyat Katılığı, Calvo Parametresi

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AR	Anderson- Rubin Test
CBRT	Central Bank of Republic of Turkey
FIML	Full Information Likelihood Method
GMM	Generalized Method of Moments
IFS	International Financial Statistics
IMF	International Monetary Fund
K	Kleibergen Test
MLE	Maximum Likelihood Estimation
NKPC	New Keynesian Phillips Curve
OECD	Organisation for Economic Cooperation and Development
TSI	Turkish Statistical Institute
US	United States
WB	World Bank

CHAPTER 1

INTRODUCTION

Understanding the characteristics of price and so the inflation dynamics is an important concept in macroeconomics because implementation of the appropriate course of monetary policy relies on the essence of the inflation dynamics. Therefore, price dynamics is important for the execution of monetary policy and central banks. In addition, inflation targeting has been used by monetary policy or central banks in recent years. Because the purpose of those central banks is to target inflation, they need to understand how the existing prices in the economy which underlie official inflation measures behave to keep the target.

Price dynamics enables policymakers to understand inflation. An important component of price dynamics is the unwillingness or incompetence of price setters to alter prices which leads to the theme of price stickiness. The degree to which prices are sticky is a crucial parameter when evaluating the impacts of monetary policy in the recent macroeconomic models. This stickiness has important implications for inflation dynamics and hence for the conduct of monetary policy. Consequently, how often and also how much prices change is a fundamental question for policymakers. Price dynamics for an economy can be modelled by examining the New Keynesian Phillips Curve of the economy since this curve enables to learn about price dynamics.

Phillips (1958) discovered a relation between inflation and unemployment. The curve which shows the inverse relation is named as Phillips Curve. According to this, there is a negative relationship between inflation and unemployment. However, Friedman (1968) asserted the falsity of this inverse relation. In addition, in 1970s, both inflation and unemployment increased at the same time in United States due to shocks in oil supply. Thus, the relation which the curve shows seemed reasonable not in the long run but in the short run, which made Friedman (1968) right.

Afterwards, different specifications including expectations augmented and microeconomic-founded type of the curve was started to be derived. Lucas (1976) states that in order to have a good model, the macroeconomic model should include microeconomic backgrounds. Therefore, NKPC is regarded as a better model compared to the traditional one due to its microeconomic foundations.

New Keynesian Phillips Curve enables to know and understand the price dynamics or inflation in an economy which is important for the application of the suitable monetary policy. There are two basic models of NKPC in Gali & Gertler (1999) which are the benchmark or baseline model of NKPC and the hybrid model of NKPC. The benchmark NKPC specifies the current inflation as a function of expected inflation of one period ahead and current real marginal cost. They have extended the baseline model of NKPC to allow for a subset of firms that set prices according to a backward looking rule of thumb to obtain the hybrid model. This has allowed them to directly estimate the degree of departure from a pure forward looking model needed to account for the observed infation persistence. The hybrid NKPC specifies the current inflation as a function of expected inflation of one period ahead and one lag of the inflation and current real marginal cost. Therefore, the difference between the two main models is that the hybrid model includes the inflation inertia variable. All of the firms have a forward looking behavior in the baseline model which is also called the pure forward looking model while there are also firms which have a backward looking behavior in the hybrid model.

NKPC includes individual optimization of the firms subject to restrictions on the frequency of price adjustment. It is regarded as better compared to the traditional phillips curve due to its theoretical modelling of inflation dynamics and explicit use of microfoundations. NKPC can be derived by presuming optimizing behavior on the side of firms that determine their prices following a time dependent rule, as in Calvo (1983). There exist assumption of constraints on the timing of the price changes in the form of Calvo (1983) contracts such that firms can only modify price after a random interval of time has passed in the NKPC model used in this study. Hence, using Calvo staggered pricing mechanism in NKPC estimation for a country gives the average price stickiness duration for that economy.

Gali & Gertler (1999) shows specifications on NKPC model including the baseline or benchmark model and the hybrid one. Gali & Gertler (1999) uses marginal cost, expected future inflation in their benchmark model, and marginal cost, expected future inflation lag of inflation in their hybrid model. They estimated the price stickiness parameter for US economy, which is seen as the closed economy model.

There are various studies on NKPC. Some of them including Ifrim (2014), Ahrens & Sacht (2014) and Foroni & Marcellino (2014) have used the purely forward looking model of Gali & Gertler (1999) depending on the baseline model, and other studies like Dufour, et. al. (2010), Kichian & Rumler (2014), and Malikane & Mokoka (2014) have used the hybrid model. In addition, there exist some studies involving Gali & Gertler (1999), Yazgan & Yılmazküday (2005), Cespedes, et. al. (2005) and Vasilev (2015) which have estimated both of the baseline and the hybrid model.

New Keynesian Phillips Curve is usually estimated by Hansen's (1982) GMM analysis to quarterly observations. However, Fuhrer et al. (1995) has shown that GMM suffers from a small sample bias, and conluded that sample data must include critical amount of observation to reach the reliable estimates. Ahrens & Sacht (2014) uses daily observations including four years to achieve such higher observation amounts. This study, however uses monthly data with almost sixteen years, which is a better case than using quarterly data. By using monthly data, it is tried to achieve reliable estimates of price stickiness parameter for Turkey. However, there are many debates on this analysis technique. Identification problem which is related to the validity of the instrument set is one of these problems. In this study, J-statistics is used to see whether the instrument set and accordingly the model is valid or not.

There are also many debates on specifications and the anaysis technique in the estimation of NKPC. In NKPC estimation, different specifications of marginal cost are used instead of output gap, and this may yield different results. Because some scholars think that there exists identification problem in estimating NKPC by GMM estimation, they started to use identification robust methods to estimate the NKPC for an economy. This study investigates the New Keynesian Phillips Curve for Turkey using Calvo (1983) staggering price mechanism with monthly data between January-1999 and March-2016 due to the availability of the data. In addition, it follows the methodology of Ahrens & Sacht (2014), which also uses that of Gali and

Gertler (1999). We have estimated the baseline model of NKPC by using Generalized Method of Moments analysis with the variables including the inverse intertemporal elasticity of substitution for domestic goods, the inverse intertemporal elasticity of labor, the inverse elasticity of money demand, the substitutability between domestic and foreign goods from the viewpoint of the domestic consumer, the substitutability between goods produced in different foreign countries, the discount factor, and the degree of openness, consumer price index, interest rates of both Turkey and Germany and with the instrument set change in inflation, change in exchange rate, and the interest rate.[1]

For the Turkish case, NKPC studies which depend on the macro data are very limited. These studies include Yazgan & Yılmazküday (2005), Saz (2011), Gözgör (2013), Eruygur (2011). On the other hand, there exist some studies like Şahinöz & Saraçaoğlu (2008) and Özmen & Sevinç (2016) which have used micro price data in order to look into the price stickiness duration in Turkey. The lower price stickiness duration in microstudies compared to the macrostudies which confirms the findings of Ellis (2009) and Abe & Tonogi (2010) which states that lower frequency data leads to the lower price stickiness duration. Frequency of the data of the Özmen & Sevinç (2016), for example, is higher than that of Yazgan & Yılmazküday (2005) and Eruygur (2011), and the average price stickiness duration is lower in the former.

The study is organized as follows: The second section gives information on New Keynesian Phillips Curve and describes the methodology of Gali & Gertler (1999) and Ahrens & Sacht (2014) depending on that of the former. The third section gives the literature about the NKPC studies which include Calvo staggering price mechanism. The fourth section describes the Generalized Method of Moments analysis used in the study. The fifth section explains the data, the empirical analysis and the results of the study. The last section concludes.

[1] Yazgan & Yılmazküday (2005) have found empirical support for the benchmark NPKC for Turkey.

CHAPTER 2

NEW KEYNESIAN PHILLIPS CURVE

New Keynesian Phillips Curve (NKPC) models price dynamics and so inflation. In NKPC, expected future inflation is a significant factor in explaining current inflation. In addition, real marginal cost is the main driving force behind the inflationary process. It has two basic model specifications which are called the baseline and the hybrid model of NKPC. According to the baseline NKPC, current inflation is a function of real marginal cost and expected future inflation. In the hybrid specification, however, there is also one more variable which is one lag of inflation which shows backward looking behavior.

NKPC is derived from optimizing agents, and it assumes that in any given period each of the existing firms has a fixed probability $1-\theta$ that it may reset its price during that period. Therefore, there is a probability θ that firms do not alter their prices. Such a mechanism is called Calvo (1983) pricing mechanism. By using some calculations, the average duration of price stickiness is found thanks to this pricing mechanism. Hence, NKPC estimation of Calvo price parameter gives information about the average price stickiness duration in an economy.

Because NKPC estimation of Calvo stickiness parameter enables to learn about the price dynamics and also price stickiness for an economy, investigation of the NKPC is important for the application on monetary policy. If average duration of price stickiness is low, then monetary policy may not have a real effect meaning that the effects of the applied policies may not be observed due to the high degree of price variation. In other words, monetary policy can be effective if prices are sticky.

Gali & Gertler (1999) have proposed two basic models of NKPC which include benchmark or baseline NKPC, and the hybrid NKPC. Inflation has only forward looking behavior parameter in the benchmark specification additional to real marginal cost variable while it has both the forward and backward looking behavior

parameters in the hybrid case. Therefore, the firms may have pure forward looking behavior or both the forward and backward looking behavior at the same time. Because Gali & Gertler (1999) have estimated the NKPC by using the data of United States, the model in their study has been thought as an example of closed economy version of NKPC estimation.

As Eruygur (2011) has pointed out that studies on NKPC estimations have many criticisms and conflicting results in the literature due to some reasons. First, it is important to decide which variable to include as the proxy of marginal cost in the NKPC equation. Second, choosing the correct model is crucial which means that whether the baseline model or the hybrid model is valid for the specified country. In addition, country specific parameters like degree of openness, form of production function must be taken into account. Third, estimation technique must be carefully chosen in case there is weaknesses of some estimation techniques in some models.

Real marginal cost variable in the equation is important in that it shows the real activity in the economy. Another important criticism is due to inclusion of which variable for the proxy of the marginal cost variable in the NKPC equation. Some studies use output gap while others use unit labor cost for the proxy of the real marginal cost variable, which is also controversial. According to Gali & Gertler (1999), marginal cost measure directly accounts for the impact of productivity gains on inflation which is a factor that output gap measures often miss. Furthermore, it is widely known that traditional measures of the output gap involve a significant amount of measurement errors which is primarily because of being unobservable of the theoretical measure of 'natural level' of output. Malikane (2012) has shown that specifications of NKPC may suffer from the negative sign problem on the output gap in emerging market economies.

Inclusion of openness variable is important in NKPC estimation. The model which is used in Gali & Gertler (1999), have been criticized in that its application is for United States which is seen as a closed economy. Therefore, it has no variable related to openness of the country like exchange rate. Having lived in a globalized world, however, NKPC specification for countries must consider openness of country since prices in these countries are mostly affected due to this openness feature or trade. This point is important since most of the studies for estimation of

NKPC in different countries are based on the study of Gali & Gertler (1999). Turkey is a small open economy, so openness variable is needed for the estimation of the NKPC.

Eruygur (2011) agrees the importance of the inclusion of the parameter of openness while estimating NKPC for small open economies like Turkey. It states two important things for the estimation of NKPC. Firstly, the effect of exchange rate and terms of trade shocks on the pricing mechanism and so on the inflation must be considered while estimating NKPC. The second one is about importance of imported goods on firms' marginal costs and decisions. According to Eruygur (2011), inclusion of openness in the NKPC model complicates the model since imported intermediate and final goods, exchange rate dynamics and terms of trade shocks must be definitely considered.

There are some studies including Barkbu & Batini (2005), Batini, et. al. (2005), Rumler (2007), Leith & Malley (2007), Bjornstad & Nymoen (2008) which have obtained supportive results for the open economy specification of the NKPC model. However, the studies of Bardsen et. al. (2004), Balakrishnan &Lopez-Salido (2002) have obtained either insupportive or insufficient results for the open economy version of NKPC estimations. The studies including Matheson (2008) and Rumler & Valderrama (2010) examine forecasting performance of the open economy NKPC models.

Selection of the correct model among the baseline case and the hybrid one is also criticized. There are disagreements whether the NKPC equation must include only the backward looking component or both of the backward and forward component. For example, the baseline NKPC is criticized for some different reasons due to the giving impractical results related to inflation dynamics. According to Christiano, et. al. (2005) and Fuhrer & Moore (1995), inflation exhibits a prominent degree of inertia which contrasts with the assumption of baseline case of Gali & Gertler (1999).

Eruygur (2011) states one more critism on NKPC estimation which is about the dominance of the forward or backward looking behavior in determining the inflation process. Some studies including Gali & Gertler (1999), Gali, et al. (2001,2005),

Sbordone (2002,2005), Gagnon & Khan (2005), Kurmann (2007), Kleibergen & Mavroeidis (2009) have obtained that forward looking behavior dominates the backward one while Fuhrer & Moore (1995), Fuhrer (1997), Rudd & Whelan (2005) and Lindé (2005), have found that the backward looking behavior is more dominant.

Another important criticism is on estimation technique. Generalized Method of Moments analysis has been used in NKPC estimations of Gali & Gertler (1999) and most of the studies after it. However, Rudd & Whelan (2005) and Lindé (2005) have argued that some of the empirical findings of Gali & Gertler (1999) are the result of the specification bias associated with the GMM procedure. Nevertheless, Gali et. al. (2005) has argued that their estimates are robust to a variety of estimation techniques including the GMM estimation of the closed form solution and the nonlinear instrumental variables.

For the Turkish case, NKPC studies which depend on the macro data are very limited. These limited studies including Yazgan & Yılmazküday (2005), Saz (2011), Gözgör (2013), Eruygur (2011) have some different features compared to this study like having different data range and frequency, inclusion of no country specific variables on openness, or different assumption on the production function. On the other hand, there exist some microstudies which investigate the price stickiness duration in Turkey including Şahinöz & Saraçoğlu (2008) and Özmen & Sevinç (2016). These studies have not used macro data and found the Calvo price stickiness parameters. However, their findings of price stickiness duration is lower which may occur due to use of high frequency data and low data period compared to than those of the macroeconomic models.

In summary, there are ongoing debates on NKPC estimations. The first issue is about which variables to be included in the estimation of the NKPC estimation. For this case, whether the proxy of real marginal cost will be the unit labor cost or output gap is important. The second issue is about modeling approach like having the baseline case or the hybrid case of the Phillips Curve. The last issue is about estimation approach. There are many estimation approaches, like some form of GMM, MLE, and Bayesian, etc. Some studies have found the results that GMM has some identification problems and such an estimation approach may lead specification bias and incorrect sign or magnitude of the estimated parameters. Therefore, it is thought

that identification robust methods may give better estimation results instead of GMM. However, it is thought that increasing the sample size may help to remove the problem of biasedness.

2.1. Gali & Gertler's NKPC Model

In this subsection, two models that are made used of in the study will be given. Section 2.1.1 and 2.1.2 describes the models of Gali & Gertler (1999) to estimate NKPC while section 2.2 describes that of Ahrens & Sacht (2014) whose specification also depends on the former.

Gali & Gertler (1999) develops two basic models for the estimation of inflation dynamics using Calvo (1983) staggered pricing mechanism. These models include the bencmark and the hybrid model of NKPC. In the benchmark model, current inflation is a function of real marginal cost and expected future inflation. In the hybrid model, lag of the inflation is added to the model in addition two the benchmark case, meaning that current inflation depends on real marginal cost, expected future inflation and lag of inflation. The models in the study is estimated for United States, which is considered as closed economy. Therefore, the models in this study is seen as the closed economy NKPC models. Nevertheless, there are mamy studies on NKPC estimation which are generally based on the study of Gali & Gertler (1999).

2.1.1. The Baseline/Benchmark NKPC

Gali & Gertler (1999)'s model specification of the NKPC is as follows: It is assumed that there exists Cobb-Douglas type production fuction. If A_t denote technology, K_t denote capital, and N_t denote labor, then Y_t, the output is given by

$$Y_t = A_t K_t^{a_k} N_t^{a_n} \tag{1}$$

Then, real marginal cost is given by the ratio of the wage rate to the marginal product of labor,

$$MC_t = \left(\frac{W_t}{P_t}\right) / \left(\frac{\partial Y_t}{\partial N_t}\right) \tag{2}$$

By using (1), it is obtained that $MC_t = \left(\frac{S_t}{a_n}\right)$, where $S_t = \frac{W_t N_t}{P_t Y_t}$ is the labor income share, or real unit labor costs.

By letting lowercase letters show percent deviations from the steady state it is obtained that

$$mc_t = s_t. \tag{3}$$

If equations (1) and (3) are combined then the inflation equation can be obtained by the optimization of firms in such a framework with Calvo pricing as

$$\pi_t = \lambda s_t + \beta E_t\{\pi_{t+1}\}, \tag{4}$$

where the coefficient λ is given by

$$\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta} \tag{5}$$

Here, θ represents the Calvo price stickiness parameter, meaning that firms do not reset their prices with the probability θ. In addition, β indicates the discount parameter.

Because under rational expectations the error in the forecast of π_{t+1} is uncorrelated with information dated t and earlier, it follows from (4) that

$$E_t\{(\pi_t - \lambda s_t - \beta\pi_{t+1})z_t\} = 0 \quad (6)$$

where z_t is a vector of variables dated t and earlier. Therefore, it is orthogonal to the inflation surprise in period $t+1$. Then, the orthogonality condition given in (6) forms the basis for estimating the model via Generalized Method of Moments.

Equation (5) is substituted into equation (6) to obtain the direct estimates of θ. Then the following specification is obtained

$$E_t\{(\theta\pi_t - (1-\theta)(1-\beta\theta)s_t - \theta\beta\pi_{t+1})z_t\} = 0 \quad (7)$$

Besides making these specifications, Gali & Gertler (1999) also estimated the structural parameters of θ and β by using (7).

2.1.2. The Hybrid Model of NKPC

The difference of the model from the above model is that it lets the inflation inertia. In this model, Gali & Gertler (1999) extends the basic Calvo's assumption to allow some firms to set prices by using a backward looking rule of thumb. By using their formulation, fraction of firms that belongs to backward looking rule of thumb behavior is estimated as well as the price stickiness parameter θ.

There exists again the same assumption that each firm is able to alter its price in any given period with a fixed probability $1-\theta$ which is independent of the time the price has been fixed. The difference of the model from the pure forward looking model is that there exist two type of firms. Forward looking firms constitutes $1-\omega$

as a fraction of all of the firms. These firms act like the ones in Calvo model like setting prices optimally, using all of the accessible information to estimate future marginal cost. The remaining firms, which are fractionally ω of all firms are referred as backward looking firms and use simple rule of thumb which is based on the recent history of the aggregate price behavior. By making the required specifications, the hybrid Phillips Curve equation is obtained:

$$\pi_t = \lambda mc_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1}, \tag{8}$$

where,

$$\lambda = (1-\omega)(1-\theta)(1-\beta\theta)\emptyset^{-1} \tag{9}$$

$$\gamma_{f=}\beta\theta\emptyset^{-1} \tag{10}$$

$$\gamma_{b=}\omega\emptyset^{-1} \tag{11}$$

$$\emptyset = \theta + \omega[1-\theta(1-\beta)] \tag{12}$$

Here, γ_f and γ_b represents the forward looking and backward looking parameters, respectively.

2.2 Ahrens & Sacht's Model of NKPC Estimation

Based on the studies of the model of Gali & Gertler (1999), it has been developed a model by Ahrens & Sacht (2014) for the estimation of the NKPC. The equations in this part of the study belongs to that of Ahrens & Sacht (2014). Ahrens & Sacht (2014) of NKPC specification is as follows:

$$\pi_t = \beta(h_m)E_t\pi_{t+1} + \lambda(h_m)(\mu + mc_t^r), \tag{13}$$

where

$$\lambda(h_m) = \frac{(1-\theta(h_m))(1-\theta(h_m)\beta(h_m))}{\theta(h_m)} \tag{14}$$

β, μ, mc_t^r, $\theta(h_m)$ represent the discount factor, mark-up value, real marginal cost and the Calvo price stickiness parameter, respectively. In addition, h_m denotes the underlying period length.

After substituting domestic and foreign output gap instead of the last term in (13), it is obtained that

$$\pi_t = \beta(h_m)E_t\pi_{t+1} + \lambda(h_m)[(\sigma_\alpha + \eta)y_t - (\sigma_\alpha - \sigma)y_t^f] \tag{15}$$

where $\sigma_\alpha = \sigma[1-\alpha+\alpha(\sigma\gamma+(1-\alpha)(\gamma\chi-1))]^{-1}$ is a function of degree of openness and $0 \leq \alpha \leq 1$. The meanings of the remaining parameters are given in Table 1.

Table 1. The Parameters Used in the Study

σ	inverse intertemporal elasticity of substitution for domestic goods
η	inverse intertemporal elasticity of labor
ψ	inverse elasticity of money demand
χ	substitutability between domestic and foreign goods from the viewpoint of the domestic consumer
γ	substitutability between goods produced in different foreign countries
β	discount factor
α	degree of openness

Terms of trade is defined as the price of foreign goods in terms of home goods. Ahrens & Sacht (2014) follows the study of Clarida et al. (2001, 2002) and assumes that there exists a relationship between the terms of trade gap and both output gaps as

$$\frac{1}{\sigma_\alpha}(s_t - \tilde{s}_t) = y_t - y_t^f, \tag{16}$$

where s_t represents terms of trade and $\tilde{s}_t$ represents the terms of trade in the steady state. They make use of the log-linearized terms of trade.

By applying (16) on (15) they obtain the following equation

$$\pi_t = \beta(h_m)E_t\pi_{t+1} + \lambda(h_m)\left(\frac{\sigma_\alpha - \sigma}{\sigma_\alpha}(s_t - \tilde{s}_t) + (\eta + \sigma)y_t\right), \tag{17}$$

By considering the underlying intertemporal optimization problem of the representative household who seek to maximize its utility function under consideration of the related budget constraints, they apply optimal control theory on standard expressions for a separable money-in-the-utility-function, a budget and a cash-in-advance constraint known from the literature which is given as

$$y_t = m_t^r, \tag{18}$$

which means that consumption expenditures are not allowed to exceed the real money holdings of the household. m_t^r represents the real money holdings of the household. The optimality condition regarding money demand depends on the nominal interest rate

$$m_t^r = \frac{1}{\varphi}(\sigma y_t - \beta(h_m)i_t), \tag{19}$$

where φ is the inverse elasticity of money demand. After substituting (18) into (19), it is obtained

$$y_t = \left(\frac{\beta(h_m)}{\sigma - \varphi}\right)i_t. \tag{20}$$

Ahrens & Sacht (2014) rearranges uncovered interest parity theorem as

$$s_t = E_t e_{t+1} + i_t^f - i_t - p_t + p_t^f, \tag{21}$$

where i_t , i_t^f, e_t and p_t^f denotes the domestic, foreign nominal interest rate, the nominal exchange rate, and the foreign price level, respectively. The corresponding steady state expression

$$\widetilde{s_t} = \widetilde{e_t} + \widetilde{\imath_t^f} - \widetilde{\imath_t} - \widetilde{p_t} + \widetilde{p_t^f}. \tag{22}$$

Then, both of (21) and (22) leads to the following equation denoted as Type I NKPC in their study

$$\pi_t = \beta(h_m) E_t \pi_{t+1} + \lambda(h_m)[\emptyset_1 \left(E_t \Delta e_{t+1} + \Delta i_t^f - \Delta i_t - \Delta p_t + \Delta p_t^f\right) + \emptyset_2 i_t], \tag{23}$$

with

$$\emptyset_1 = \frac{\sigma_\alpha - \sigma}{\sigma_\alpha} \tag{24}$$

$$\emptyset_2 = \frac{(\eta + \sigma)\beta(h_m)}{\sigma - \varphi} \tag{25}$$

It is defined a gap by $\Delta a_t = a_t - \widetilde{a_t}$ with $a_t = \left\{e_t, i_t, i_t^f, p_t, p_t^f\right\}$ and $\widetilde{a_t} = \left\{\widetilde{e_t}, \widetilde{\imath_t}, \widetilde{\imath_t^f}, \widetilde{p_t}, \widetilde{p_t^f}\right\}$.

Within this specification, the driving forces of domestic inflation are the domestic nominal interest rate, the expected bilateral nominal exchange rate gap, the domestic and nominal and foreign interest rate gaps, and the domestic and foreign price level gaps.

By substitution of the expectation error $\varepsilon_t = \beta(h_m)(E_t[\pi_{t+1}] - \pi_{t+1})$, they obtain a regression equation of the form

(26)

$$\pi_t = \beta(h_m)\pi_{t+1} + \frac{(1-\theta(h_m))([1-\theta(h_m)\beta(h_m)])}{\theta(h_m)}\xi_{1,t} + \varepsilon_t,$$

with $\xi_{1,t}=\{\emptyset_1(E_t\Delta e_{t+1} + \Delta i_t^f - \Delta i_t - \Delta p_t) + \emptyset_2 i_t\}$ since it is Type 1 NKPC specification.

McCallum (1976) shows that under rational expectations, the prediction error of future inflation ε_t is uncorrelated to the information set available to the forecaster z_t, which comprises information dated at time t or earlier. This assumption implies that $E_t[\varepsilon_t z_t]$=0. Applying this condition to equation (26), it is obtained

$$E_t[(\theta(h_m)\pi_t - \theta(h_m)\beta(h_m)\pi_{t+1} - (1-\theta(h_m))(1-\theta(h_m)\beta(h_m))\xi_{1,t})z_t] = 0 \quad (27)$$

with z_t being a vector of instruments.

The orthogonality condition given by (27) then constitutes the basis for estimating the model by way of Generalized Method of Moments (GMM).

In their study, Ahrens & Sacht (2014) have used different instrument sets with their lags, and chosen the set which gives minimum J-statistics and a higher probability value after running the GMM estimation.

In our case, we also have tried different instrument sets, some of which was the same with theirs and there was also some different instrument sets. We have chosen the instrument set which has given minimum J-statistics and higher probability value. Our valid instrument set includes four lags of change in inflation, foreign country 3-month interest rate, and exchange rate. The results of our study are given in Chapter 5.3.

CHAPTER 3

LITERATURE REVIEW ON CALVO PRICING MECHANISM

There are many studies about New Keynesian Phillips Curve estimation which uses different variables, different specification method, and different estimation technique. After it was noticed that real marginal cost is an important key factor in determining inflation dynamics, output gap or unit labor cost is used for the proxy of real marginal cost variable in the NKPC equation. Some studies estimate the NKPC by assuming forward behavior of the inflation process in which Calvo staggering pricing mechanism is used. In this way, the price stickiness parameter or Calvo price stickiness parameter is found. This parameter shows the average price stickiness duration in the economy. The remaining studies estimate the NKPC by using the hybrid model which states that both forward and backward looking behavior of inflation in addition to the real marginal cost variable determines the current period of inflation. In the hybrid model, both the price stickiness parameter and ratio of the forward or backward looking firms are found. Because the study has focused on finding the estimates of Calvo price stickiness parameter and so the average price stickiness duration, we have searched for the literature including the Calvo pricing mechanism of the NKPC estimation.

Gali & Gertler (1999) have estimated the purely forward looking New Keynesian Phillips Curve using Calvo pricing mechanism for the United States. They have used real marginal cost variable as the relevant determinant of inflation. The time span includes 1960:1-1997:4 quarterly US data. They have used Generalized Method of Moments as an estimation technique, and their instrument variables include four lags of inflation, the labor income share, the output gap, the long-short interest rate spread, wage inflation, and commodity price inflation. Because it is said that using GMM estimation in nonlinear models which has small sample is sometimes

sensitive, they have applied two specifications to make estimations with same instrument sets. They have found the Calvo price stickiness parameter θ=0.83 and θ=0.88 for these two specifications. It means that prices are fixed for between nearly five and six quarters on average, which is close to the survey evidence in that country. They also have pointed out that labor share does not render an exact measure of real marginal cost, so the price stickiness parameters is likely to be biased upward. They have concluded that the NKPC estimation with forward looking behavior may give a resonably good illustration of inflation dynamics.

Cespedes, Ochoa, and Soto (2005) have estimated the baseline NKPC model for Chile for the quarterly period 1990:1-2004:4. They have made different specifications in terms of both production function and marginal cost type. They have used four lags of the deviation of inflation from target, the deviation of real marginal cost from trend, the output gap, two lags of the monetary policy interest rate, three lags of nominal wages growth relative to trend, and four lags of terms of trade deviations from trend as instrument set. They have found different ranges for different specifications. The range is θ=0.85-0.91 when capital is freely mobile, and θ=0.55-0.80 when it is firm specific. They also have estimated the hybrid NKPC model using again Calvo pricing model, and found the price stickiness parameter as 0.65, concluding that the average price stickiness in Chile within the given year is about 3 quarters.

Yazgan & Yılmazküday (2005) have estimated the Calvo parameter of NKPC for Turkey by using GMM analysis. They have used quarterly data over the period 1988:2-2003:1. Real marginal cost has been used as the key driving force behind the inflation process instead of output gap. They have found θ=0.41, meaning that the average price stickiness duration in Turkey between the given period is 1.7 quarters. They used one lag of inflation and growth of exchange rate as instruments in the analysis. Identification robust tests like Anderson & Rubin (1949)'s AR test and Kleibergen (2002)'s K test were applied beside the Hansen's J test.

Dufour, Khalaf and Kichinan (2010) have estimated the Calvo price stickiness of NKPC for US between the quarterly period 1982:3-2006:4. They have used different specification and two different instrument sets for each of the specifications. The

values of the Calvo parameter estimates are in Table 1. They concluded that the average price duration in US for the given period is in 1.85 and 2.27 quarters for the first specification, and 1.25 and 1.14 quarters for the second specification.

Daniskovă & Fidrmuc (2011) have estimated some specifications of the New Keynesian Phillips Curve for the Czech Republic between 1996:1 and 2009:2. They have shown that GMM suffers due to the problem of weak instruments which leads to biased estimates. Additionally, they have concluded the Full Information Maximum Likelihood (FIML) analysis is robust and yields significant estimates of structural parameters implying a strong forward looking behaviour for the country. They have found that the average price stickiness parameter varies from 3.4 quarters to 9.8 quarters. Morever, it has been found that roughly a half of the firms are backward looking.

Eruygur (2011) has estimated different version of NKPC equation for Turkey which considers openness and imported intermediate and final goods structure of the country. The study was country specific, and novel in the literature of Turkish case. It has used CES (Constant Elasticity of Substitution) type production function. The data is quarterly with the range between 1988:1 and 2009:4. It has made two different specifications for the analysis. The results have shown that the average price stickiness of Turkey is 8-9 months, meaning that on average prices remain fixed for 8-9 months.

Kichian & Rumler (2014) have estimated Calvo stickiness parameter of NKPC for the quarterly period of 1984:1-2008:3 for Canada. They have used four different specifications including closed economy basic NKPC specification, closed economy semistructural NKPC specification, and open economy basic NKPC specification, and open economy semistructural NKPC specification. The average price stickiness duration is found to be 5 quarters, 2 quarters, 3 quarters, and 2 quarters respectively.

Ifrim (2014) has estimated the basic NKPC for the economy of Romania. The data is quarterly with a sample from 2000:1–2013:4 for the economy. The Calvo parameter's posterior distribution has been found very close to its prior, having a mean of 0.67, which implies that the average duration of prices in the Romania economy is 3 months.

Ahrens & Sacht (2014) have estimated the duration of average price stickiness parameter for Argentina by using the daily data between the period 12.03.2007 and 04.02.2011. They have used the pure forward looking NKPC specification. Their result has shown that the average price stickiness duration in Argentina within the given period is 2-3 months.

Choudhary, et al. (2016) have estimated the price stickiness for Pakistan using some interview data between periods of December 2009 –March 2010 and June 2010 – October 2011. They have studied the price setting in Pakistan using 1189 structured face to face interviews of managers organized by the State Bank of Pakistan– Pakistan's Central Bank. They have found the quarterly Calvo probability using median duration as 0.25, which means that implied median price spell in months is equal to 4 months.

Özmen & Sevinç (2016) have investigated the duration of consumer price spells and price change patterns for Turkey by employing a comprehensive micro price data covering around 6,000 items over four years. They have analyzed how long typical price spell lasts and investigated the size, frequency, distribution and synchronization of price changes. They have concluded that a higher frequency of price changes has been estimated compared to advanced economies with a mean duration of the spell of 1.9 months. They have pointed out that the duration of price spells within consumer prices is not homogeneous. For example, food prices on average stay for shorter periods than the overall consumer prices, while services prices, on average, stay longer. They have also added that the average duration is 2.5 months when all items are considered and weighted by sub-groups.

The Calvo price stickiness parameter values of NKPC estimations in the literature as well as the country name, data frequency and period ant included instrument sets are given in Table 2. It is seen that many different specifications, data frequency and range, instrument sets are used in these studies. There exist differences in terms of the specification of the explanatory variable, modelling and estimation techniques.

The first point is related to not having the exact measure of the real marginal cost. Since real marginal cost is an important explanatory variable in NKPC estimation,

and it is not observable, one has to use some proxies instead of it when estimating NKPC. There exist varying specification to obtain more valid proxy of the real marginal cost in the studies of the Table 2.

The second point is about different estimation techniques used in NKPC estimation like GMM and some forms of GMM, FIML estimation, Bayesian techniques, etc. Moreover, many different instrument sets are used while estimating GMM. Recently, there are debates on GMM estimation for giving biased estimates due to the small sample sizes and weak instrument problem. Therefore, recent studies try to estimate the NKPC equation by using identification robust methods. There are some tests like AR and K tests which are evaluated as identification robust tests.[2]

The third point is related to the model selection. Selection of the baseline model or the hybrid model leads different estimates of stickiness parameter. Additionally, the results may change when some country specific parameters like type of production function, openness, and exchange rate, etc. are added to the model.

Most of the studies in the Table 2 have used quarterly data of the countries except the ones of Ahrens & Sacht and Özmen & Sevinç (2016) and However, as Lindé (2005) asserts, GMM suffers from biasedness due to small sample size. Since our study uses monthly data of the variables, we have more data points. Therefore, the possibility of the biasedness may not exist. This problem may also be removed by using different specification in GMM.

Table 2 illustrates the average price stickiness duration found in the studies. The duration of average price stickiness is very long for most of the countries in the table while it is very short for Argentina, Romania and Turkey, and Pakistan. The duration of the average price stickiness is longer for Turkey compared to Argentina. Such a results in the literature can be obtained due to some reasons. Some studies including Ellis (2009) and Abe & Tonogi (2010) has shown that lower-frequency data tends to overstate the true price stickiness. The study on Argentina may be due to this reason. For the Turkish case, as Eruygur (2011) mentions, the study includes the openness variable in the model. Therefore, it considers the exchange rate differences in the estimation. Turkey is exposed to exchange rate differences very much since it

[2] For detailed information see Anderson & Rubin (1949) and Kleibergen (2002).

imports some of the final goods and also most of the intermediate goods from abroad. All of the reasons may be the reason of the shorter period of price stickiness duration. For the Romania, utilization of different estimation tecnique may result in different average price stickiness period.

The difference in the duration of the average price stickiness may be attributed to be counted as an example of a developed country or not. Price stickiness in developed countries like United States, Czech Republic and Canada is lower compared to the other countries.

It may be the reason that the data period affects the Calvo price stickiness parameter and so the duration of average price stickiness. The countries which have financial difficulties or economic crisis in the period in which NKPC is estimated may have lower average duration of price stickiness due to price instabilities in such economic conditions.

Table 2. Literature on Estimations of Calvo Price Stickiness Parameter

Study	**Country**	**Data**	**Instrument set /** **Required information**	**Calvo parameter /** **Duration**
Gali, Gertler (1999)	United States	Quarterly 1960:1- 1997:4	Four lags of inflation, the labor income share, the output gap, the long-short interest rate spread, wage inflation, and commodity price inflation	θ=0.83 θ=0.88 Duration: 5 to 6 quarters on average
Cespedes, Ochoa, Soto (2005)	Chile	Quarterly 1990:1-2004:4	Four lags of the deviation of inflation from target, the deviation of real marginal cost from trend, the output gap, two lags of the monetary policy interest rate, three lags of nominal wages growth relative to trend, and four lags of terms of trade deviations from trend	(capital freely mobile): θ=0.85-0.91 Duration: 6.7 to 11 quarters on average (firm specific capital) baseline: θ=0.55-0.80 hybrid : θ=0.65 Duration: 2.2 to 5 quarters on average
Yazgan, Yılmazküday (2005)	Turkey	Quarterly 1988:2- 2003:1	One lag of inflation and one lag of growth of exchange rate	θ=0.407 Duration: 1.7 quarters on average
Dufour, Khalaf, Kichinan (2010)	United States	Quarterly 1982:3-2006:4	Two specifications and two instrument sets 1)fourth and fifth lag of each of inflation and marginal cost 2) fourth and fifth lags of each of inflation, marginal costs, the unemployment rate, and the change in the real price of the non-produced good in the economy	First specification θ =0.56; 0.46 Duration:1.85 to 2.27 quarters on average Second specification θ =0.20; 0.12 Duration: 1.13 to 1.25 quarters on average
Eruygur (2011)	Turkey	Quarterly 1988:1-2009:4	Continuous Updating Estimation Iterated GMM Estimation	Duration: 8-9 months on average

Table 2. Literature on Estimations of Calvo Price Stickiness Parameter (Continue)

Study	**Country**	**Data**	**Instrument set / Required information**	**Calvo parameter / Duration**
Daniskovă, Fidrmuc (2011)	Czech Republic	Quarterly 1996:1-2009:2	FIML estimation	Duration: 3.4 to 9.8 quarters on average
Kichian, Rumler (2014)	Canada	Quarterly 1984:1-2008:3	Four specifications which are closed economy basic and semistructural NKPC specification, and open economy basic and semistructural NKPC specification	Closed economy: θ=0.58, 0.553; Open economy: θ=0.663, 0.811 Duration:5,2,3,2 quarters on average
Ifrim (2014)	Romania	Quarterly 2000:1-2013:4	Not GMM, but Bayesian Techniques	θ =0.6702 Duration: 3 months on average
Ahrens, Sacht (2014)	Argentina	Daily 12.03.2007-04.02.2011	GMM and AR test	Daily: θ=0.9867 ; Monthly: θ =0.6667 Quarterly: θ =0.0002 Duration: 2 to 3 months on average
Foroni, Marcellino (2014)	United States	300 monthly observations	Structural DSGE, Mixed frequency Simulated data. (1000 replications of Monte Carlo experiments)	Monthly: θ = 0.9 ; Quarterly : θ=0.893 Duration: 10 months on average Mixed frequency: θ =0.898
Özmen, Sevinç (2016)[3]	Turkey	Bi-weekly frequency 10.2006-01.2011.	Comprehensive micro price data covering around 6,000 items over four years.	Mean duration of the spell of 1.9 months.

[3] It uses microdata to estimate average price stickiness.

CHAPTER 4

GENERALIZED METHOD OF MOMENTS ESTIMATION

The orthogonality condition between the error term and the regressors is the most important assumption of OLS analysis. If this assumption fails, the OLS estimator becomes inconsistent and gives biased results. Because this assumption is not satistifed in most of the situations, one should deal with this endogeneity problem. GMM analysis solves the problem by using instrument variables technique. Instrument variable set include variables which are related to endogenous regressors in the estimated equations however not related to the error term. In addition, it is applicable both for linear and nonlinear estimations.

An estimator $\hat{\theta}$ is called an extremum estimator if there is a scalar objective function $\Phi_n(\theta)$ such that $\hat{\theta}$ maximizes Φ_n subject to $\theta \in \Theta \subset \mathcal{R}^p$, where Θ is the parameter space or the set of possible parameter values. The objective function $\Phi_n(\theta)$ depends both on the estimator θ and the sample size *n*. The linear and nonlinear GMM estimators are some extremum estimators.The definitions in this part of the study are taken from Hayashi (2000).[4]

The objective function of GMM can be written as,

$$\Phi_n(\theta) = -\frac{1}{2} g_n(\theta)' \widehat{W} g_n(\theta),$$

where $g_n(\theta)$ illustrates the orthogonality conditions of the form

$$g_n(\theta) = \frac{1}{n} \sum_{t=1}^{n} g(w_t; \theta)$$

[4] For detailed information see Hayashi (2000).

Here, w_t is the set of instruments, and $\widehat{W}$ is the weighting matrix which is $K \times K$ symmetric and positive definite. K is defined as number of orthogonality conditions. Maximizing the objective function implies minimizing the distance $g_n(\theta)'\widehat{W}g_n(\theta)$.

Identification is an important issue in GMM analysis. If number of orthogonality conditions are greater than the dimension of the parameter vector, then the model is said to be overidentified. The overidentification concept helps us to conclude whether the model is compatible with the data in the sample or not.

Hansen's J-test is used for testing overidentification. The hypotheses of the J-test are as follows:

$H_O: g_n(\theta) = 0$ (The model is valid.)

$H_1: g_n(\theta) \neq 0 \; \forall \theta \in \Theta$ (The model is invalid.)

Under H_O, the below J-statistics has a χ^2 distribution asymptotically with *p-q* degrees of freedom, where *p* is the number of estimated parameters and *K* is the number of orthogonality conditions,

$$J = n\left(\frac{1}{n}\sum_{t=1}^{n} g_n(w_t, \hat{\theta})\right)^T \widehat{W_n}\left(\frac{1}{n}\sum_{t=1}^{n} g_n\left(w_t, \hat{\theta}\right)\right) \longrightarrow \chi^2_{K-p}$$

McCallum (1976) indicates that an orthogonality condition of like (27) can be consistently estimated with an instrument variable technique. As Ahrens & Sacht (2014) states, estimating such an equation with this technique has become the standard in the literature since Gali & Gertler (1999). In addition, Hansen's J-test (1982) is applied to check the validity of the instrument list and overidentification.

We expected to have low *J-statistics* values and high probability of the *J-statistics* to comment on the results. In our case, we have one parameter to estimate which is average price stickiness parameter. Since we have three instruments at the last stage, number of orthogonality condition is equal to three.

In the study equation (27) is estimated by GMM analysis with many different instrument sets. It is obtained that both significant and insignificant results. In the

end, we have chosen the instrument set which gives lower *J statistics* and higher probability of the *J-statistics.*

J-statistics is the most common diagnostic utilized in GMM estimation to evaluate the suitability of the model. A rejection of the null hypothesis implies that the instruments are not satisfying the orthogonality conditions required for their employment. This may be either because they are not truly exogenous, or because they are being incorrectly excluded from the regression.[5]

New Keynesian Phillips Curve is usually estimated by Hansen's (1982) GMM analysis to quarterly observations. However, Fuhrer et al. (1995) has shown that GMM suffers from a small sample bias, and conluded that sample data must include critical amount of observation to reach the reliable estimates. Ahrens, Sacht (2014) uses daily observations including four years to achieve such higher observation amounts. This study, however uses monthly data with almost sixteen years, which is a better case than using quarterly data. By using monthly data, we try to achieve reliable estimates of price stickiness parameter for Turkey.

According to Batini, et. al. (2005), GMM is generally used to deal with the expectation terms like in equation (27). It has been told that using GMM is more efficient and robust due to exploitation of orthogonality conditions between some function of the parameters and a set of instrument variables.

[5] See the Baum, et. al. (2003) for detailed information.

CHAPTER 5

ESTIMATION, DATA AND RESULTS

In this chapter of the study, the data and empirical analysis will be initially explained. Then the results of the study will be given. Additionally, some figures and graphs which have been used in the study will be illustrated.

5.1. Empirical Analysis and Data

In this study equation (27) will be estimated, which is called as Type I NKPC. Because the estimation is done for Turkey, Turkey constitutes the domestic economy. Germany is taken as foreign economy because it is the most important trading partner of Turkey, i.e. Turkey exports to Germany mostly. The most important export partners of the Turkey is given in Figure 3.

The data set comprises monthly observations for Turkey and Germany from January-1999 to March-2016. Inflation of Turkey is derived by calculating monthly change in Consumer Price Index CPI. The CPI and interest rate data of Turkey are taken from International Financial Statistics of IMF. Exhange rate data is taken from CBRT due to the availability of the required period. Because of omitting six zero in Turkish lira, some modifications are made in exchange rate for the required period. Interest rates of Germany, both the monthly and 3-month interest rates, are taken from OECD database. The parameter values of the inverse elasticity of money demand and degree of openness are given in Figure 1 and Figure 2, respectively. The former converges to the value of 1.5 in recent years. The latter is nearly 0.30. In addition to the parameter values, the marginal cost variable in the baseline model of Gali & Gertler (1999) is represented by the variable $\xi_{1,t}$ in Ahrens & Sacht (2014). Therefore, $\xi_{1,t}$ is

a function of the variables which include change in exchange rate, home and foreign country interest rates and prices and also the parameters of the constant values of $\emptyset_1$ and $\emptyset_2$ which is also mentioned in (26).

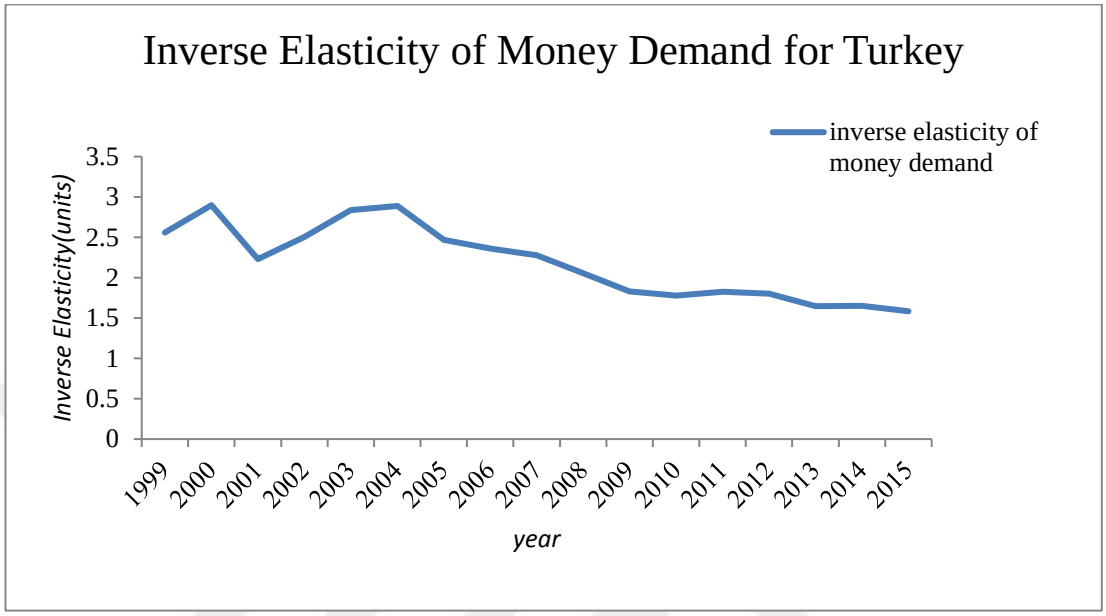

Figure 1. The Parameter of Inverse Elasticity of Money Demand for Turkey

Source: World Development Indicators, World Bank

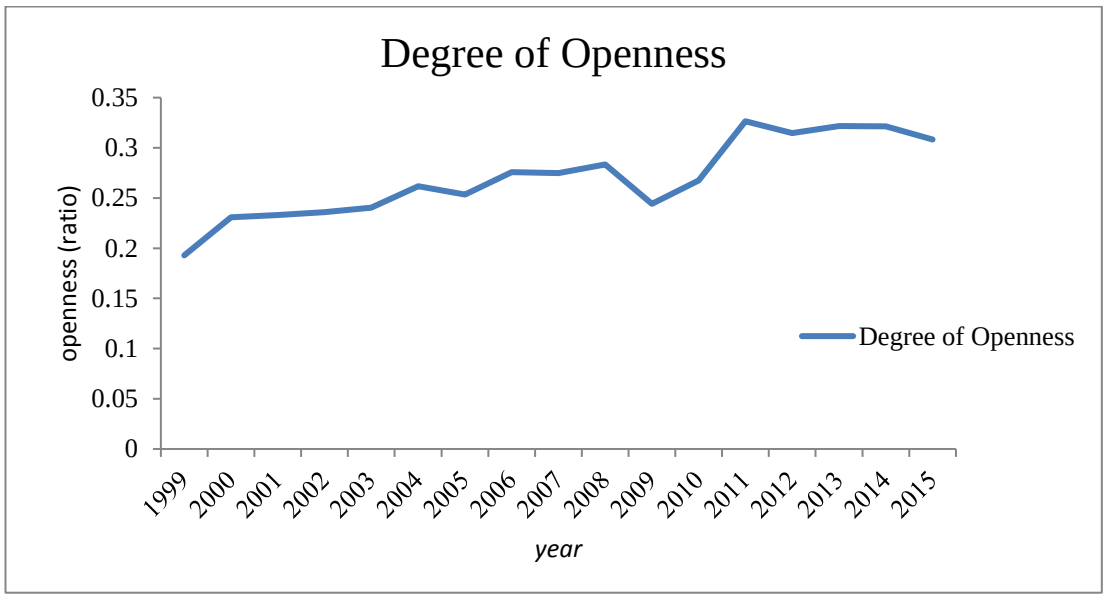

Figure 2. The Parameter of Degree of Openness for Turkey (M/GDP)

Source: World Development Indicators, World Bank

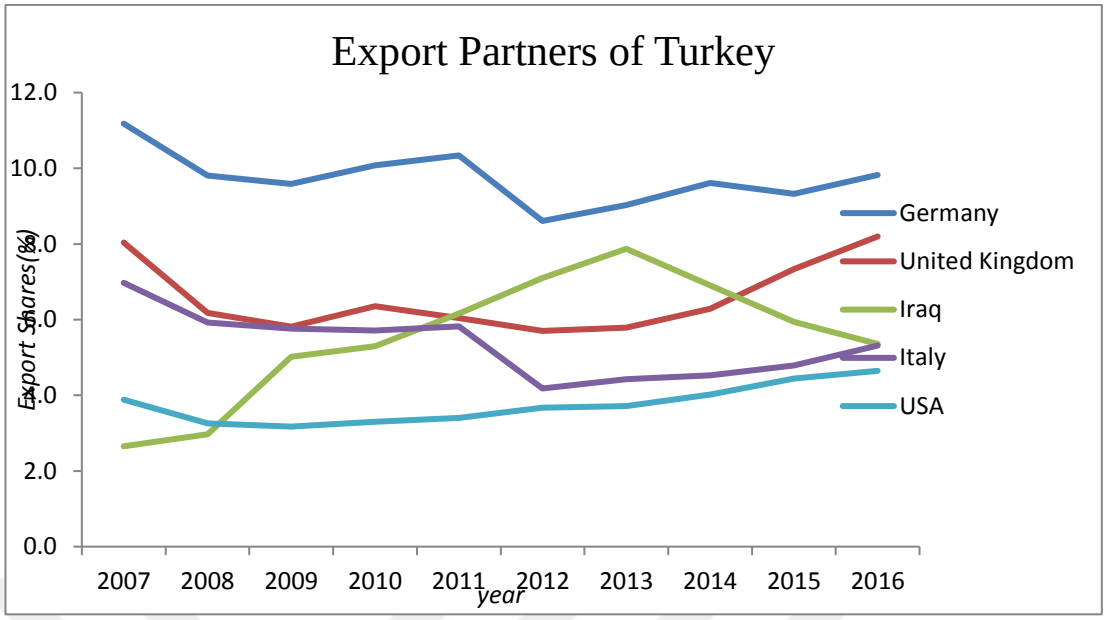

Figure 3. Export Partners of Turkey with the Export Share Rates

Source: Turkish Statistical Institute

Figure 3 shows the volumes of the export of Turkey. It is seen that the most important export partner is Germany, that is why we have used Germany as the foreign country in the model.

There are some parameters which have been used in the model, of which their meanings are given in Table 1. The parameter σ, the inverse intertemporal elasticity of substitution for domestic goods is taken from Agenor, et. al. (2012) and Agenor & Alper (2012). The parameter η, the inverse intertemporal elasticity of labor is taken from Christiano (2005) and Middleditch (2010). The parameter ψ, the inverse elasticity of money demand is calculated by using the database of World Bank. Additionally, the roughly parameter value of inverse elasticity of money demand can be found in Agenor, et al. (2012) and Agenor & Alper (2012). Due to the lack of the data availability for the two parameters, namely the parameter χ and γ, which shows the the substitutability between domestic and foreign goods from the viewpoint of the domestic consumer and the substitutability between goods produced in different foreign countries respectively are taken from Ahrens, Sacht (2014). The parameter β, the discount factor is taken from Agenor, et. al. (2012) and Agenor & Alper (2012) and Primus (2013). Finally, the parameter α, the degree of openness is calculated by

using import to GDP ratio of Turkey as in Eruygur (2011). All of the values of the parameters are given in Table 3.

Table 3. The Parameter Values Used In the Study

Parameters	σ	η	ψ	χ	γ	β	α
Values	1.66	1	1.5	1.175	0.99/3.5	(0.95-0.99)	0.30

Different instrument sets with their lags have been tried in the estimation. The set of instruments is selected based on the criteria that they satisfy the overidentifying restrictions of Hansen's J-test. The results show that the most suitable instrument set includes four lags of changes in inflation, Germany 3-month interest rate, and exchange rate. The estimation has also been done for the period after 2002 to see whether the estimation is robust. The reason why the year 2002 has been chosen is due to monetary policy changes in Turkey after 2001 economic crisis. Similar results have been obtained compared to the previous case. The value of average price stickiness parameter has decreased a little, which has resulted in minor decrease in the average duration of not changing the prices.

5.3 Results

Equation (27) has been estimated via Generalized Method of Moments estimation technique. The results of the estimation of the Calvo parameter of the baseline NKPC model for Turkey, the calculated average price stickiness duration, and the probability values of the J-test of overidentifying restrictions are given in Table 4. Table 4 reports that, the average price stickiness parameter has been found in the range of (0.77-0.80) for the period 1999-2016, while it is in the range of (0.73-0.76) after the period of 2002.

The results seem significant with high probability values of J-statistics. Because the average duration of price stickiness implied from θ is calculated as $1/(1-\theta)$, the

average price stickiness duration is between 3 to 5 months, which means that on average prices change once in 3-5 months in Turkey.

The duration of the average price stickiness in Turkey is very short compared to that of the many countries in Table 2. There may be some reasons of it both from empirical and country-specific point of views. From empirical view, the results confirm the study of Ellis (2009) and Abe & Tonogi (2010) which have found that lower-frequency data tends to overstate the true price stickiness. Since the studies done for Turkey related to NKPC estimations have used the quarterly data, in general, the estimated duration of average price stickiness may have been found longer. From the country-specific view, it can be told that Turkey is a country which imports final goods and even most of the intermediate goods. Therefore, it is very vulnerable to exchange rate differences or shocks. When there are some fluctuations in the exchange rate, it actually spreads to the prices in the country.

For some countries like United States, Canada, Czech Republic, however, the average price stickiness parameter is higher which corresponds to the higher average price stickiness duration. This is probably due to a stable inflation period as becoming a developed country.

Our results are in line with those of Yazgan & Yılmazküday (2005). We have found shorter duration of price stickiness compared to Eruygur (2011) while longer but close duration of price stickiness compared to Özmen & Sevinç (2016). These findings may be attributed to the data frequency which has been used because Eruygur (2011) has used the quarterly data while Özmen & Sevinç (2016) have used the bi-weekly microprice data to estimate the price stickiness duration. To our knowledge, however, there exists no study to justify our results of NKPC estimation for Turkey that has used the monthly frequency.

The results proves the conclusion that there is ongoing debates in NKPC estimations since there are different estimation results even for a one country. These differences may surely occur due to the difference in time period and time frequency for the country. However, there exist differences due to the different specifications, varible selection, proxy variables (for marginal cost, for example), estimation methods like GMM, some forms of GMM, Bayesian techniques, FIML, etc., and instrument sets.

Table 4. Estimation Results of the The Calvo Price Stickiness Parameter

Equation	Calvo Parameter (θ)	Average Duration	Prob (J-statistics)
1	0.778172 (0.06299)	4.507997	0.5733
2	0.733557 (0.05385)	3.753148	0.8864
3	0.802461 (0.053831)	5.062291	0.4712
4	0.762793 (0.046351)	4.215727	0.7865

All of the four equations has instrument sets of four lags of change in inflation, change in Germany 3-month interest rate, and change in exchange rate. Differently, while the parameter $\gamma$is 0.99 for 1 and 2; it is 3.5 for equation 3 and 4. While equations 1 and 3 have the data range of 1999-2016, equations 2 and 4 shows the same estimations of 1 and 3 respectively for the period of after 2002. Standard errors are given in brackets. We have used the default HAC (Newey West) matrix as an estimation weighting matrix. We have used the iterate to convergence weight updating process and achieved the convergence in 18, 8, 17, 8 iterations, respectively.

CHAPTER 6

CONCLUSION

Understanding the characteristics of price and so the inflation dynamics is an important concept in macroeconomics because implementation of the appropriate course of monetary policy relies on the essence of inflation dynamics. Inflation targeting has been used by monetary policy in recent years. Because the purpose of some central banks is to target inflation, they need to understand how the actual prices in the economy which underlie official inflation measures behave to keep the target.

Price dynamics enables policymakers to understand inflation. An important component of price dynamics is the unwillingness or incompetence of price setters to change prices which leads to the theme of price stickiness. The degree to which prices are sticky is a key parameter when evaluating the effects of monetary policy in the recent macroeconomic models. This stickiness has important implications for inflation dynamics and hence for the conduct of monetary policy. Consequently, how often and also how much prices change are fundamental questions for policymakers. Price dynamics of an economy can be understood by examining the New Keynesian Phillips Curve of the economy since this curve enables to learn about price dynamics.

New Keynesian Phillips Curve enables to know and understand the price dynamics or inflation in an economy which is important for the application of the suitable monetary policy. There are two basic models of NKPC in Gali & Gertler (1999) which are the benchmark or baseline model of NKPC and the hybrid model of NKPC. The benchmark NKPC specifies the current inflation as a function of expected inflation of one period ahead and current real marginal cost. The hybrid NKPC specifies the current inflation as a function of expected inflation of one period

ahead and one lag of the inflation and current real marginal cost. All of the firms have a forward looking behavior in the baseline model which is also called the pure forward looking model while there are also firms which have a backward looking behavior in the hybrid model.

NKPC includes individual optimization of the firms subject to restrictions on the frequency of price adjustment. It is regarded as better compared to the traditional phillips curve due to its theoretical modelling of inflation dynamics and explicit use of microfoundations. NKPC can be derived by assuming optimizing behavior on the side of firms that set their prices following a time dependent rule, as in Calvo (1983). Using Calvo staggered pricing mechanism in NKPC estimation for a country gives the average price stickiness duration for that economy.

NKPC shows the dynamics of the inflation process in the country. By looking at the results of the estimations of NKPC for a country, some policy analysis can be proposed, or efficient monetary policy can be achieved. However, it is necessary to develop a good model of NKPC because there are ongoing debates on the specifications and estimations of it such as using the essential variables, the better proxies for the marginal cost, better estimation methodologies, and more robust or powerful estimation techniques.

Many studies related to NKPC literature have used the quarterly data. However, there are some studies like Ellis (2009) and Abe & Tonogi. (2010) which supports the idea that using low frequency data for NKPC estimation leads to higher price stickiness parameter and so the higher duration of average price stickiness. In addition, the time periods in the analyses are important because countries may have financial difficulties in their economies which may ruin the duration of the average price stickiness.

In this study, we have used the monthly data to estimate the NKPC estimation for Turkey between the period January-1999 and March-2016 by using the methodology of the Ahrens & Sacht (2014) and Calvo (1983) price mechanism. We estimate the model by using Generalized Methods of Moments (GMM) analysis with different instrument sets including change in inflation which is calculated by consumer price index, change in foreign country interest rate, and change in exchange rate. We use

the sample data taken from IFS of IMF, OECD and CBRT. We also need some parameters for the estimation of the model, and we take them from some research papers and articles. We have found that the Calvo price stickiness parameter for Turkey within the given period is in the range (0.73-0.80), meaning that the average price stickiness duration is approximately 3-5 months. Therefore, we have concluded that the average price changes occur once in every 3-5 months in Turkey for given parameters. This study differs from the general literature of NKPC estimation for Turkey due to the coverage of the data period, the frequency of data and the type of methodology which is applied.

When we look at the results of the previous studies on NKPC estimation, the analysis done for the developed countries is usually have higher duration of average prickiness compared to the countries which are not seen as developed countries. This may be due to a stable inflation period in the developed countries. In other words, countries with high inflation rates may have higher duration of average price stickiness.

In relation to other studies for Turkey, the estimates in this study is in line with other studies in the literature including Yazgan & Yılmazküday (2005) and the micro-price study of Şahinöz & Saraçoğlu (2008). However, we have found shorter duration of average price stickiness compared to the estimates of Eruygur (2011) which may occur due to applied data frequency and the time period of the study.

In summary, NKPC estimation is important for giving information on price dynamics or stickiness in an economy because application of a suitable monetary policy depends on the price dynamics and so the inflation. However, one must be careful while estimating the curve since there are ongoing debates related to the curve. As of suggestions, one can try to find better suited production function which belongs to the relevant country, more accurate proxies of real marginal cost in the model, more powerful estimation techniques, and to include the country specific variables in the estimation of the model of the New Keynesian Phillips Curve equations.

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APPENDIX: TEZ FOTOKOPİSİ İZİN FORMU

Fen Bilimler Enstitüsü [ ]

Sosyal Bilimler Enstitüsü [x]

YAZARIN

Soyadı : Lisan

Adı : Selda

Bölümü : İktisat

TEZİN ADI (İngilizce): New Keynesian Phillips Curve Estimation for Turkey: A Monthly Analysis

TEZİN TÜRÜ: Yüksek Lisans [x] Doktora [ ]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]

2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]

3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. [x]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: