A Thresold Regression Estimation of Philips Curve: Turkey Case

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Philips Eğrisinin Eşik Regresyon İle Tahmini: Türkiye Örneği

Özet

Bu çalışmada, Hansen (1996, 2000) tarafından geliştirilen eşik regresyon modeli kullanılarak, enflasyonun oluşumunda önemli role sahip değişkenlerle genişletilmiş bir Phillips Eğrisi ilişkisi tahmin edilmiştir. Ayrıca, Hamilton (2001)'in esnek doğrusal olmayan çıkarım yaklaşımıyla doğrusal dışılığın varlığı ve eşik regresyon modelinin uygunluğu test edilmiştir. Bulgularımıza göre, Kapasite Kullanım Oranları değişkeni için %75'lik bir eşik değere sahip olan model Türkiye'deki Phillips eğrisi ilişkisi için oldukça uygundur. Bu sonuç, yüksek ve düşük Kapasite Kullanım Oranlarının enflasyon üzerinde farklı etkilere sahip olduğu yönündeki iddiaları desteklemektedir. Ayrıca, Phillips Eğrisi konusunda Türkiye ekonomisi için yapılan diğer çalışmalardan farklı olarak, çalışmamız reel ekonomik aktivite ve enflasyon arasında istikrarlı bir doğrusal dışı ilişki sunmaktadır.

***Anahtar Kelimeler*:** Phillips Eğrisi, Eşik Değer Regresyon, Esnek Doğrusal Olmayan Çıkarım, Kapasite Kullanım Oranları, Türkiye.

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Abstract

In this paper, using the threshold regression model developed by Hansen (1996, 2000), we estimated an extended Phillips curve relationship with variables playing an important role in the formation of inflation. We also used Hamilton's (2001) flexible nonlinear inference approach to test whether nonlinearity existed and if the threshold model was appropriate. According to our findings, the model in which the estimated threshold value for capacity utilization rate is equal to 75% is quite reasonable for modeling the Turkish Phillips curve. This result supports the idea that high and low capacity measures may have different impacts on inflation. Moreover, unlike other studies in Turkish Phillips Curve literature, it presents a stable nonlinear relationship between the real economic activity and inflation in Turkish economy.

Keywords: *Phillips Curve, Threshold Regression, A Flexible Nonlinear Inference, Capacity Utilization, Turkey*.

1. Introduction

The short run Phillips curve is an important tool in estimating inflation and implementing monetary policy. The consuetudinary specification of the Phillips curve implies a relationship between inflation and lagged values of an unemployment gap (Phelps, 1967; Friedman, 1968) or output gap (Sachs, 1980; Gordon, 1997). The reliability of this specification was weakened due to certain factors such as unexpected supply shocks, reforms in labor markets, the Lucas critique, and non-accelerating inflation rate of unemployment (NAIRU) etc. However, the existence of augmented versions of specification, advances in nonlinear modeling techniques and the adaptation of an inflation-targeting system are some simple reasons to consider the Phillips Curve relationship to be useful for the monetary policy of an open economy. Due to the direct relationship between monetary policy, AD-AS and inflation under the inflation targeting system via the transmission mechanism (see Svensson, 1999, 2000) as Mankiw (2001: 45-46) stated, the trade-off between inflation and real economic activity is inexorable in understanding the business cycle and short run effects of monetary policy.

To reach an augmented Phillips curve model, a simple followed by researchers is to include lagged values of inflation (inertia) and other variables that may play an important role in the formation of inflation such as oil shocks, import shocks, money growth and capacity utilization rates (see Staiger et al., 1997; Belton and Cebula, 2000; Gordon, 1997). Variables such as oil shocks and import shocks indicate supply shocks because of an increase or decrease in both oil price and openness of economy. Money growth is also an important variable in inflation, which was originally put forth by Friedman (1963). Additionally, there are numerous studies that claim capacity utilization rates can be used as an indicator of future inflation pressures by assuming that high capacity utilization levels are related to increasing marginal costs of production in the short run (see McElhattan, 1978, 1985; Gittings, 1989; Bauer, 1990; Garner, 1994). This issue has an importance on estimating inflation especially in a developing economy like Turkey because of capacity constraint hypothesis. For example, Kandil (1998: 805) reported that less developed economies are generally characterized by more binding capacity constraints compared to more developed economies.

In addition, with several nonlinear modeling techniques, researchers also take the possible asymmetries and instabilities of the Phillips curve into account (see for example Hamilton, 2001; Turner, 1997; Eliason, 2001). Eliason (2001:1) stated that assuming linearity in inflation responds to real economic activity is too restrictive. Indeed, there are several theories that indicate an asymmetric relationship, including the capacity constraint model, costly adjustment model and the monopolistically competitive model. Further, with nonlinear models, researchers allow the parameters to vary over time in accordance with the Lucas critique (1976).

To this end, this study estimates the Phillips curve relationship extended with other variables, which may play an important role in the formation of inflation within a threshold regression framework with the methodology developed by Hansen (2000). This paper splits the sample into two regimes. Hansen's approach both estimates a level with a threshold variable, which is exogenously given, and allows the instability in the marginal effects of explanatory variables around this threshold value. We also use Hamilton's (2001) approach to test whether nonlinearity exists and if the threshold model is appropriate. In this context, we use seasonally adjusted quarterly data including inflation, capacity utilization rates, output gap, import shocks and the growth rate of M2 for the Turkish economy from 1991Q1 to 2010Q4. Following related literature, we estimate threshold regressions for the Phillips curve relationship for Turkey by considering different threshold variables.

From the beginning of 1980's, Turkey has implemented economic reforms and liberalization policies. During this period Turkish economy experienced with several economic crisis. Although Turkey implemented various stabilization programs supported by IMF, high and volatile inflation persisted until 2002. The exchange rate-based stabilization program, adopted in December 1999, ended following the November 2000 and February 2001 crises. After these crises, a new strengthened stabilization program was implemented under a flexible exchange rate regime. Turkey signed a standby agreement with the IMF in May 2001 called "Turkey's Program for Transition to a Strong Economy". Squeezing inflation was the main target of this stabilization program. After the Central Bank of Turkey began implementing an inflation-targeting regime in the beginning of 2002, inflation stabilized around single digit rates starting in 2004.

The literature on the Turkish Phillips curve has conflicting results. To the best of our knowledge, four formal empirical researches have been produced on the issue. Using linear models, Onder (2004) forecasted inflation in Turkey and found that the forecasting performance of the Phillips curve model is better than other models. Kustepeli (2005) investigated the Philips curve relationship by considering different models, including the NAIRU specification, and concluded that there is no evidence of a Phillips curve for all specifications of annual and semiannual data sets. Onder (2009) estimated the Phillips curve relationship with regime-shifting models and indicated that there is no evidence on the asymmetry of the Turkish Phillips curve; changes in policy regime may have given rise to instability. Hasanov et.all (2010) investigated possible nonlinearities in the inflation - output relationship in Turkish economy by using bivariate time varying smooth transition regression models. They reported that the relationship is regime dependent and varied across time in Turkey.

In this respect, the present study contributes to the literature by examining the presence of possible asymmetric relationships in a threshold regression form. Moreover, unlike other studies, it holds formation of inflation with augmented version of the relationship and indicates a stable nonlinear relationship between the real economic activity and inflation in Turkish economy. According to our findings, the model in which the estimated threshold value for capacity utilization rate is equal to 75% is quite reasonable for modeling the Turkish Phillips curve. This result supports the idea that high and low capacity measures may have different impacts on inflation. Our findings also echo that the capacity constraint is a valid hypothesis for Turkey as a developing economy similarly found in Telatar and Hasanov (2006).

The rest of paper is organized as follows. Section 2 describes the econometric methods used. Section 3 presents model specification. Section 4 gives detailed information regarding the data set and estimation results of the model and finally section 5 concludes.

2. Econometric Methodology

To assess the Phillips curve relationship within a threshold regression framework for the Turkish economy, we use two econometric methods, namely flexible nonlinear inference and sample splitting threshold regression, which were proposed by Hamilton (2001) and Hansen (2000), respectively.

2.1 A Flexible Nonlinear Inference

Hamilton (2001) developed a new procedure that does not hold any specific functional form for the conditional mean function; parameters are used to characterize this function, and these parameters are estimated by maximum likelihood or Bayesian methods.

Hamilton (2001) suggests a novel regression model:

$$y_t = \mu(x_t) + \varepsilon_t \tag{1}$$

where, y_t is a scalar dependent variable; x_t is a k- dimensional vector of explanatory variables; and ε_t is an error term with zero mean which is independent of explanatory variables and their lagged values.

The basic idea of Hamilton's approach is to treat not only the dependent variable y_t as a realization of a stochastic process but also to consider the functional form of the conditional mean function $\mu(x_t)$ itself as the outcome of a random process. In this procedure, it is assumed that the conditional mean $\mu(x_t)$ is a combination of a linear part and a stochastic nonlinear part as in equation (2):

$$\mu(x_t) = \alpha_0 + \alpha_1' x_t + \lambda m(g \odot x_t) \qquad (2)$$

where, α_1 and g are $k \times 1$ vectors of the parameters; and α_0 and λ are scalars; $\odot$ indicates element-by-element multiplication. When $\lambda = 0$, the conditional expectation is linear and equation (1) becomes a standard regression model. The parameter g governs the curvature of $\mu(x_t)$.

Testing that the true relation is linear requires testing the null hypothesis of $\lambda = 0$ in equation (2). Under the null, the relationship is not linear, and the parameters g that govern the scale of the nonlinearity in equation (2) are not identified.

For any choice of z, $m(z)$ is a realization from a random field with the distribution as:

$$\begin{aligned} & m(z) \sim N(0,1) \\ & E\left[m(z)' \, m(z) \right] = H_k(h) \end{aligned} \qquad (3)$$

where, $h \equiv \frac{1}{2}\left[(z-w)'(z-w) \right]^{1/2}$, and $H_k(\cdot)$ is specified as:

$$H_k(h) = \begin{cases} G_{k-1}(h,1) / G_{k-1}(0,1) & \text{if } h \le 1 \\ 0 & \text{if } h > 1 \end{cases} \qquad (4)$$

where, $G_k(h,r) = \int_h^r \left(r^2 - z^2\right)^{k/2} dz$, and $r \ge h \ge 0$.

Hamilton (2000: 541) gives a recursive calculation for $G_k(h,r)$ and closed form expressions for $k = 1, 2, ..., 5$.

Under such circumstances, Hamilton (2001: 558) proposed the *LM* statistic below:

$$v^2 = \frac{\left[\tilde{\varepsilon}' H \tilde{\varepsilon} - \tilde{\sigma}^2 tr\left(MHM\right)\right]^2}{\tilde{\sigma}^4 \left(2tr\left\{MHM - Mtr\left(MHM\right)/\left(T-k-1\right)\right]^2\right\}\right)} \tag{5}$$

where, $\tilde{\varepsilon}$ is a $T \times 1$ residual vector, which can be obtained from performing a linear regression of y_t on $\left(1, x_t'\right)'$, and $\tilde{\sigma}^2$ is an estimated OLS variance. The matrix $M = I_T - X\left(X'X\right)^{-1} X'$ for X the $T \times \left(k+1\right)$ matrix, whose tth row is $\left(1, x_t'\right)'$ and the $\left(i, j\right)$ element of the matrix H is given in equation (4). Under the null hypothesis, $v^2 \sim \chi^2_{(1)}$.

2.2 Sample Split Threshold Regression

To test the existence of threshold effect, we use Hansen's (1996, 2000) approaches, which present some new results on the threshold autoregressive (TAR) models introduced by Tong (1978). In particular, Hansen (2000) proposes a data-sorting method, which allows the data to endogenously split the sample into two regimes with an exogenously given variable, called the "threshold variable", for threshold estimation methods in the regression context. In addition, Hansen (2000) develops an asymptotic distribution theory and a method to construct asymptotic confidence intervals for the regression estimates by considering ordinary least squares (OLS) regression and inverting the likelihood ratio (LR) statistic.

Consider the following two-regime structural forms in the TAR model:

$$y_t = \theta_1' x_t + \varepsilon_{1t} \qquad \text{if } q_t \le \gamma \tag{6}$$

$$y_t = \theta_2' x_t + \varepsilon_{2t} \qquad \text{if } q_t > \gamma \tag{7}$$

where q_t is the threshold variable, which can or cannot be a regressor, and is used to split the sample into two regimes. Terms y_t and x_t are dependent variable vectors and explanatory variable matrix respectively. Random variable ε_{it} is a regression error term of property white noise *i.i.d.*, and γ denotes the threshold parameter. When the threshold value is known, the model can be easily estimated using OLS. However, the threshold value is unknown *a priori,* so it should be estimated. It is clear that if the values of the threshold variable are smaller than the threshold parameter, it requires the estimation of equation (6), while larger values require that the model estimates equation (7).

The threshold regression model implies that the regression parameters differ depending on the value of the threshold variable. Defining the dummy variable $d_t(\gamma) = \{q_t \le \gamma\}$, where $\{\cdot\}$ is the indicator function, with $d_t = 1$ if $q_t \le \gamma$ or $d_t = 0$ otherwise, and setting $x_t(\gamma) = x_t d_t(\gamma)$, the model can be rewritten in a single equation:

$$y_t = \theta' x_t + \delta' x_t(\gamma) + \varepsilon_t \tag{8}$$

where, $\theta = \theta_2$ and $\delta = \theta_1 - \theta_2$. Defining $S_1(\gamma) = \hat{\varepsilon}_t(\gamma)\hat{\varepsilon}_t(\gamma)$ as the residual sum of squares of estimating the OLS regression parameters, θ, δ and γ, the optimal threshold level can be chosen to minimize $S_1(\gamma)$ such that:

$$\hat{\gamma} = \arg\min_{\gamma} \{S_1(\gamma)\}. \tag{9}$$

Conditional on $\hat{\gamma}$, equation (9) is linear in θ and δ, yielding the conditional OLS estimates of $\hat{\theta}(\gamma)$ and $\delta(\gamma)$ by regression of the dependent variable on the explanatory variables.

Equation (8) allows the marginal effects of explanatory variables on the dependent variable to vary around a threshold value of any variable, which can or cannot be a regressor. The important point in equation (8) is to determine whether the threshold effect is statistically significant. To test for no threshold effects amounts simply to testing the null hypothesis $H_0 : \gamma = \gamma_0$, implying linearity against the two-regime model, where γ_0 denotes the true value of γ. Under the null hypothesis, the threshold $\hat{\gamma}$ is not identified, and the distributions of classical tests such as t-test are nonstandard. Therefore, Hansen (1996, 2000) suggests a Lagrange Multiplier (LM) test, which is not only heteroskedasticity consistent but also autocorrelation robust for a threshold regression, as well as the bootstrap method to simulate the asymptotic distribution of following LR test for H_0:

$$LR_1(\gamma) = \{S_1(\gamma) - S_1(\hat{\gamma})\} / \sigma^2 \tag{10}$$

where, $S_1(\gamma)$ and $S_1(\hat{\gamma})$ are the residual sum of squares under $H_0:\gamma=\gamma_0$, and $H_1:\gamma\neq\gamma_0$, respectively, and $\hat{\sigma}^2$ is the residual variance under H_1. Testing the null hypothesis in a standard framework, as in equation (10), requires the auxiliary assumption that ε_t is $i.i.d.\sim N\left(0,\sigma^2\right)$. The likelihood ratio test of the null hypothesis is rejected for large values of $LR_1(\gamma)$ (see Hansen, 2000: 582).

Because the asymptotic distribution of $LR_1(\gamma)$ is not standard and strictly dominates the χ^2 distribution, Hansen (2000: 584) tabulated valid asymptotic confidence intervals for the estimated values of threshold with the no-rejection region $c(\alpha)=-2\log\left(1-\sqrt{1-\alpha}\right)$, where $c(\alpha)$is the α percent critical value. A test of $H_0:\gamma=\gamma_0$ is rejected at the asymptotic level α if $LR_1(\gamma)$ exceeds $c(\alpha)$. To test more than one threshold value, the procedures mentioned above should be applied until the null hypothesis can no longer be rejected.

3. Model Specification

In the basic Phillips curve relationship, inflation (π_t) is specified to be a function of the unemployment gap (lagged difference between the natural rate of unemployment and actual unemployment) and the lagged values of inflation. Because the output gap ($\tilde{y}_t$) variable provides a useful signal to the monetary authority, the output gap replaces the unemployment gap, as the measure of aggregate demand is relative to aggregate supply.

In addition, as mentioned in section 1, supply shocks and monetary shocks may play an important role in the formation of inflation. Therefore, we extended the model with import shock and monetary shock variables[1]. Import shocks are important in the small open economy because an increase or decrease in inflation in a foreign country will affect input prices. In addition, due to the close relationship between money growth and inflation, it is expected that monetary shocks have an important role on inflationary expectations.

Additionally, starting with McElhattan (1978), a group of studies indicates that capacity utilization rates can be used as an indicator of future inflation. The basic idea is that when resource usage approaches its maximum levels, there will be an

[1] Kibritcioglu (1999), and Kibritcioglu and Kibritcioglu (1999) stated that movements in oil price have not significantly affected Turkish inflation. Therefore, we did not break down Turkish imports into oil and non-oil imports.

increase in the marginal costs of production in the short run. For instance, Belton and Cebula (2000: 1861) stated that when resource usage is low, capacity utilization rates can act as a substitute for the unemployment variable. However, when resource usage approaches its maximum potential, rapid movements in prices tend to be associated with capacity constraints. On the other hand, it is argued that some factors such as greater openness of economy, technological progress, strong business investment and increasing the degree of competitiveness have weakened the link between domestic capacity utilization and the inflation rate (for example, see, Finn 1995; Emery and Chang 1997; Dave 2006). Moreover, Shapiro (1989) criticized the inflation-capacity utilization relationship on the basis that capacity measures are ill defined and that the relationship is spurious, respectively. Although some researchers claimed that the capacity utilization rate has become a less reliable indicator of inflationary pressure, McElhattan (1985), Gordon (1989), Garner (1994), Corrado and Mattey (1997), Belton and Cebula (2000) and Alvarez Lois (2000) provided formal references that show capacity utilization rates may play an important role in the formation of inflation. For instance, Garner (1994: 12-13) concluded that increasing openness of the economy, rapid technological change or strong business investment do not provide evidence of an upward shift in the stable-inflation capacity utilization rate, which would allow the economy to operate at higher utilization rates than in the past without worsening inflation. Hence, following the researchers' emphasis on capacity constraints, one can extend the model with the capacity utilization rate written as:

$$\pi_t = \beta_0 + \beta_1 \tilde{y}_{t-1} + \beta_2 is_{t-1} + \beta_3 ms_{t-1} + \beta_4 \pi_{t-1} + \beta_5 cu_{t-1} \qquad (11)$$

where, is_t, ms_t and cu_t indicate import shocks, monetary shocks and capacity utilization rate, respectively.

In addition, these researchers directly or indirectly investigated the threshold relationship. For example, while Belton and Cebula (2000) directly investigated the threshold relationship by identifying different threshold values as a spline knot, McElhattan (1985) and Garner (1994) both indirectly explored the threshold relationship between inflation and capacity utilization as they tried to find a stable point for the relationship. Moreover, some authors tried to find a threshold effect with output gap or inflation as a threshold variable (for example, see Demers, 2003; Dupasquier and Ricketts, 1998). In our study, we use a threshold regression form and rewrite equation (11) as follows:

$$\begin{aligned} \pi_t = & (\beta_{10} + \beta_{11} \tilde{y}_{t-1} + \beta_{12} is_t + \beta_{13} ms_{t-1} + \beta_{14} \pi_{t-1} + \beta_{15} cu_{t-1}) d[q_t \leq \gamma] \\ & +(\beta_{20} + \beta_{21} \tilde{y}_{t-1} + \beta_{22} is_t + \beta_{23} ms_{t-1} + \beta_{24} \pi_{t-1} + \beta_{25} cu_{t-1}) d[q_t > \gamma] + \varepsilon_t \end{aligned} \qquad (12)$$

where, γ indicates a threshold value for q_t, which is the threshold variable. The important point in equation (12) is whether there is a threshold effect that requires testing the null hypothesis ($H_0 : \beta_{1i} = \beta_{2i}$ for all *i* from 0 to 5) against its alternative $(H_1 : \beta_{1i} \neq \beta_{2i})$. As mentioned in section 2, however, traditional procedures of hypothesis testing cannot be applied here. If the null hypothesis cannot be rejected, that means there is no threshold effect, and the threshold parameter γ will be unidentified. Hence, we used the methodology developed by Hansen (1996, 2000) as represented in section 2.

4. Data and Empirical Findings

In this study, we used seasonally adjusted quarterly data covering the period from 1991Q1 to 2010Q4 obtained from the Republic of Turkey Central Bank. The availability of the data for capacity utilization rates determined the starting date of the estimation period. The variables under consideration are inflation as a percentage change of consumer prices; capacity utilization rate; output gap proxied by the Hodrick-Prescott filtered (logged) industrial production; import shocks as the ratio of implicit price deflator for imports to the implicit GDP deflator; and monetary shocks measured by the lagged difference of the M2 growth rate.[2]

Table 1 presents some descriptive statistics of the variables. In Turkey, the average inflation rate was around 9.33% from 1991 to 2010, whereas in the first quarter of 1994, Turkey had a maximum inflation rate of 34.50%, which can be associated with the 1994 economic crisis. Turkey's average capacity utilization rate during the same period was approximately 77.80%, ranging from a maximum of 82.90% to a minimum of 66.15%. The average output gap for the same period was 1.10%, and its largest value was about 10.60% during the first quarter of 2008. Meanwhile, while the smallest value was around -0.17% in the first quarter of 2009, which can be related to the 2008 global crisis. In addition, average import shock was 0.60, ranging from a maximum of 0.99 to a minimum of 0.28. During the same period, money growth averaged 11.26%, whereas in the third quarter of 1994, Turkey had a maximum money growth rate of 36.31%, which can be associated with the 1994 economic crisis.

[2] Before estimating the threshold regression of the Phillips curve, the non-stationary in the presence of structural breaks in each series was tested with Lee and Strazicich's (2001, 2003) minimum LM unit root test with one and two breaks; the unit root null hypotheses for all variables were rejected. Therefore, we can say that all variables included in the analysis are stationary.

Table 1: Some Descriptive Statistics for the Data

Variables	*Mean*	*Maximum*	*Minimum*	*Std. Deviation*	*Skewness*	*Kurtosis*
π_t	9.33	34.50	0.70	6.52	0.64	4.10
cu_t	77.79	82.90	66.15	3.84	-0.99	3.30
$\tilde{y}_t$	1.10	10.60	-0.17	0.06	-0.75	3.21
is_t	0.60	0.99	0.28	0.17	-0.34	2.18
ms_t	11.26	36.31	0.10	6.57	0.98	4.48

By using these variables, we primarily estimated the linear model given in equation (11). Estimation results are presented in Table 2. The linear model shows poor fit for the augmented linear Phillips curve model as expected because similar results have been reported in related studies on the Turkish Phillips curve. Hence, we employed Hamilton's (2001) procedure to test whether the true relation given in equation (11) is linear or not. The *LM* $\chi^2_{(1)}$ test statistic for the linearity null hypothesis was calculated as 281.421 (with *p*-value = 0.000), which implies that nonlinearity was quite remarkable.

Table 2: Estimation Results of Linear Model

Variables	*Linear Model*
Constant	0.0107 (0.127)
π_{t-1}	-0.022 (0.167)
cu_{t-1}	-0.173 (0.158)
y_{t-1}	0.335* (0.108)
is_{t-1}	0.353* (0.084)
ms_{t-1}	0.061 (0.067)

After detecting nonlinearity, we employed the *LM* test proposed by Hansen (1996), which allowed us to understand if a threshold effect existed for each of explanatory variables. Table 3 presents test results for the threshold effects with a lagged capacity utilization rate and output gap. Threshold effects on the measure of inflation, lagged inflation, imported inflation and monetary shock are not reported here because they gave insignificant threshold estimations.

Table 3: Test Results of Threshold Effects for Lagged Capacity Utilization Rate and Output gap

Null of no threshold for	*LM Test*	*Bootstrap p-value*	*Threshold Estimate*	*95 % Confidence Intervals*
cu_{t-1}	20.86	0.000	74.95%	[72.2% , 77.3%]
$\tilde{y}_{t-1}$	14.28	0.045	-0.017	[-6.6% , -0.16%]

According to Table 3, we found significant threshold effects for cu_{t-1} and $\tilde{y}_{t-1}$. After detecting threshold effects to determine how precise these were, we employed an LR test, as suggested by Hansen (2000), to examine the confidence interval around the threshold effect; the 95% confidence regions were estimated as 72.2% and 77.3% for capacity utilization rates and -6.6% and -0.16% for lagged output gap. Figure 1 and Figure 2 display normalized likelihood ratio sequence $LR_1(\gamma)$ statistics as a function of threshold variables.

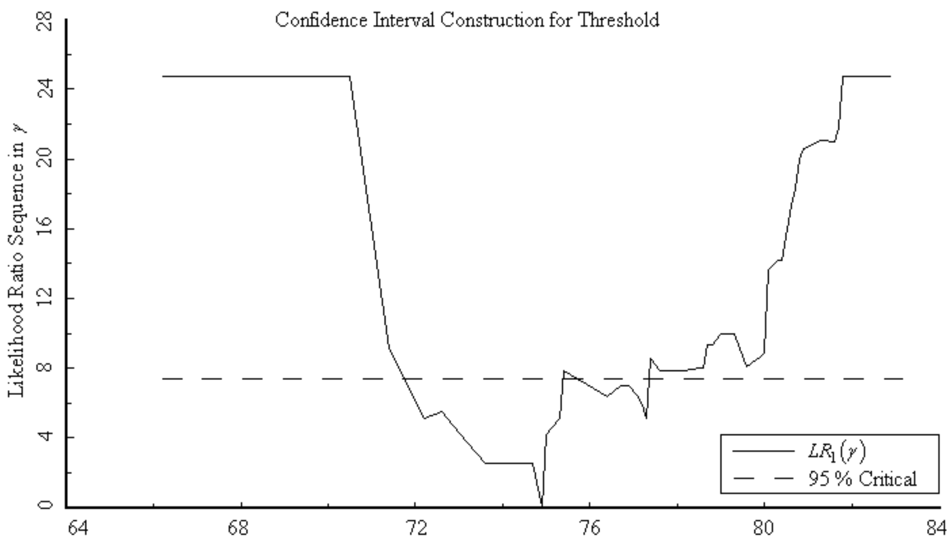

Figure 1: Sample Split: Confidence Interval Construction for Threshold Variable cu_{t-1}.

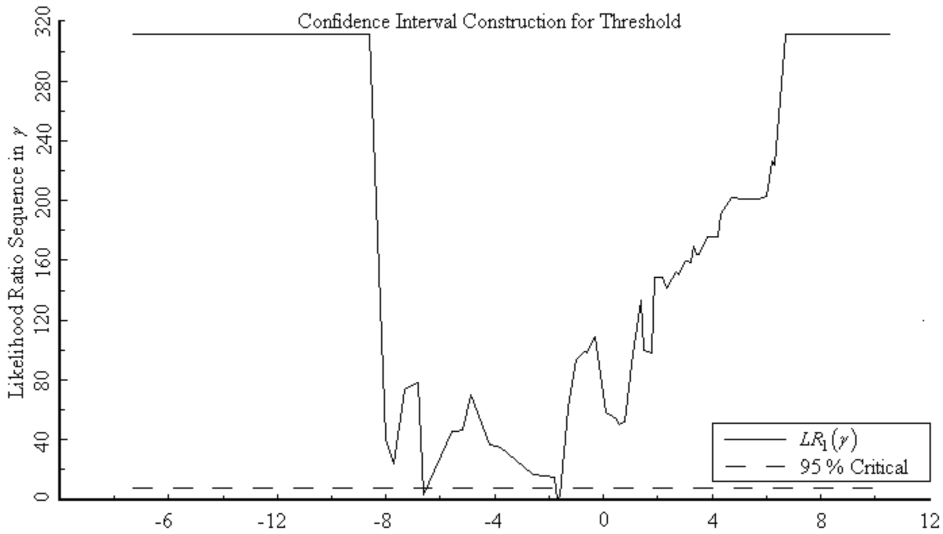

Figure 2: Sample Split: Confidence Interval Construction for Threshold Variable $\tilde{y}_{t-1}$.

After ensuring the threshold levels, we estimated threshold models in equation (12). Table 4 reports the estimation results. In the low regime, for the model in which the lagged capacity utilization rate was treated as a threshold variable, all parameters were found to be statistically significant at the 1% level except for the lagged capacity utilization rate, which was found to be statistically significant at the 10% level. These results satisfy our economic expectations because the low regime capacity utilization rate did not display any additional information, as the literature suggests. For the high regime, however, the lagged capacity utilization rate was found to be statistically significant at the 5% level, which implies that there was a complementary relationship between capacity utilization rate and output gap, thus identifying an inflationary process in Turkey. In addition, in the upper regime, all parameters were found to be significant.

The coefficient of π_{t-1} (β_{i4}), inertia, explains the role of sticky wages and prices in determining the inflation rate; it has a negative sign in the low regime and a positive sign in the high regime. Therefore, it indicates that there are no effects of sticky wages and prices in downswing phase of the economy. One possible explanation for this is the relatively poor power of trade unions in Turkey similar to other developing economies. The coefficients of is_{t-1} (β_{i2}) are estimated to be stable around 0.35 in both the low and high regimes and indicate that there is no difference in imported inflation between the regimes. Similarly, the coefficients of ms_{t-1} (β_{i3}) are estimated to be stable around 0.10 in both the low and high regimes and indicate that there is no remarkable difference in the effects of monetary shocks between the regimes. However, the coefficients of $\tilde{y}_{t-1}$ (β_{i1}) are estimated slightly different in high and low regimes. While in low regime or downswing phase of the economy, it is equal to 0.48, in high regime or upswing phase of the economy, it is equal to 0.56. Therefore, when all other factors are fixed, it implies a convex Phillips curve which is an important implication of capacity constraint hypothesis. The output cost of reducing inflation by one percentage point $\left(\frac{1}{\beta_{i1}}\right)$ is significantly smaller during an upswing phase as opposed to the output cost during a downswing phase.

Table 4: Estimations of Threshold Regression Models

	Threshold variable cu_{t-1}		*Threshold variable* $\tilde{y}_{t-1}$	
Variables	*Regime 1* ≤ 75 %	*Regime 2* > 75 %	*Regime 1* ≤ -0.017	*Regime 2* > -0.017
Constant	0.332***	-0.596**	0.358*	-0.417***
	(0.236)	(0.214)	(0.119)	(0.245)
π_{t-1}	-0.381*	0.271*	-0.241***	0.226
	(0.081)	(0.090)	(0.136)	(0.280)
cu_{t-1}	-0.553***	0.579**	-0.593*	0.353***
	(0.356)	(0.232)	(0.168)	(0.263)
$\tilde{y}_{t-1}$	0.480*	0.556**	0.464*	0.277***
	(0.120)	(0.211)	(0.097)	(0.172)
is_{t-1}	0.365*	0.350*	0.335*	0.357**
	(0.061)	(0.113)	(0.063)	(0.141)
ms_{t-1}	0.111*	0.080**	0.119**	-0.065
	(0.038)	(0.040)	(0.055)	(0.084)

Not: Standard errors, which are corrected for autocorrelation in parentheses, and *, ** and *** denote significant at 1%, 5% and 10% levels respectively.

For the model in which output gap was treated as a threshold variable, threshold was found to be negative, which means there is no evidence of the presence of menu costs or some adjustment costs of prices. A relatively high bootstrap *p*-value for threshold effects on the lagged output gap may lead to doubtful estimations for the model parameters. In addition, especially in the high regime, the parameters of lagged inflation and the monetary shocks variables were not statistically significant; other parameters were only significant at 10%. Therefore, the use of the model in which lagged capacity utilization is treated as a threshold seems more appropriate for modeling the threshold Phillips curve in Turkey. To be sure, we employed Hamilton's procedure again. For both models (cu_{t-1} and $\tilde{y}_{t-1}$ treated as threshold variables, respectively), *LM* $\chi^2_{(1)}$ test statistics equaled 1.781

(with *p*-value=0.182) and 1.898 (with *p*-value=0.168), which indicates that the null hypothesis of the threshold regression specifications could not be rejected. Therefore, it is difficult to say which one of these models is more appropriate.

Finally, to be sure of the forecasting advantages of using capacity utilization rates as a threshold variable, we computed the dynamically simulated fitted values of both threshold models. Table 4 presents Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE) and Root Mean Square Error (RMSE) statistics. From Table 5, it is evident that the threshold model with a lagged capacity utilization rate performs better. To test if the differences between these statistics are statistically significant, we implemented the Diebold Mariano (DM) test.[3] Because DM was found to be 2.653, the null hypothesis that there were no differences between the sample forecast performance of the two models could be rejected at a 1% significance level.

Table 5: Test Statistics for in Sample Forecasts

Models with threshold variables	*MAPE*	*MSE*	*RMSE*
cu_{t-1}	0.5020	0.0007	0.0271
$\tilde{y}_{t-1}$	0.5507	0.0013	0.0352

5. Conclusion

The present study examined the short run Phillips curve model extended with other important variables in the formation of inflation by considering the threshold effects. For this purpose, we used the methodology developed by Hansen (1996, 2000), which allows the data to endogenously split the sample into two regimes using an exogenously given threshold variable, for threshold estimation in the regression context. We also used Hamilton's (2001) approach to test both whether nonlinearity exists and if the threshold model is appropriate in this case.

We started our analysis testing the appropriateness of the linear specification by using the Hamilton's (2001) approach. After ensuring that linear specification is not correct, we employed the *LM* test proposed by Hansen (1996). According to the threshold effects test results, while for the model in which lagged capacity utilization rate was the threshold variable, the null hypothesis that there was no

[3] Diebold and Mariano (1995) test the null hypothesis $H_0 : E(d_t) = 0$ where d_t is the difference of the squared dynamically simulated residuals of two alternative models and shows asymptotic distribution of $T^{1/2}\,\overline{d}_t / \varpi$ is standard normal where $\overline{d}_t$ and ϖ are the sample mean and nonparametric estimate of the long-run variance of d_t, respectively.

threshold effect was rejected at a quite low significance level, the null hypothesis for the model with the lagged output gap variable as a threshold was statistically significant at only 5%. Additionally, by judging the low individual significances for the model with lagged output gap as the threshold variable, especially in the high regime, and by calculating forecast performance criteria and DM statistics based on dynamic simulations, it is clear that the model with lagged capacity utilization rate as the threshold as the appropriate one with the estimated value is equal to 75%, which is quite reasonable for the Turkish economy.

In accordance with this results, we conclude that (i) high and low capacity measures may have different impacts on inflation and the formation of inflation, as emphasized by Belton and Cebula (2000); (ii) in the low regime, capacity utilization rates do not give any additional information than does output gap; on the contrary, in the high regime, they are complements in the formation of inflation for the Turkish economy over the period under consideration; (iii) capacity constraint hypothesis holds for Turkish economy; and hence (iv) Turkish Phillips curve has a convex shape. Finally, the most striking conclusion is that (v) unlike other studies in the literature, the relationship between the real economic activity and inflation in Turkish economy presents a stable nonlinearity over the period under consideration.

As a result, one can claim that with capacity utilization rate as a threshold variable, the threshold regression model is an appropriate modeling tool for the Turkish short run Phillips curve. In this context and in the current Turkish economy, the findings of this study provide a useful framework for policy makers in estimating inflation and implementing monetary policy.

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