5. Estimating Taylor Rules with Markov Switching Regimes for Turkey[1]

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Abstract

This study examines the alternative specification of monetary policy rules during inflation targeting regime in Turkey. Original Taylor rule and Taylor rule augmented with exchange rate are estimated using the Markov regime switching models. We use monthly data for the period 2003:1-2017:7. Our findings indicate that the Turkish economy operates in two different regimes: high-interest rate regime (high regime) and low-interest rate regime (low regime). In both models, 2009 is the clear-cut year of transition between two regimes. Findings indicate both regimes to be permanent. The response to inflation in the high regime is larger compared to its low regime counterpart. A key finding is that in the high regime, the reaction to output gap is more aggressive than the reaction to inflation. This implies that, according to Central Bank of Republic of Turkey, output gap stabilization is more important than inflation stabilization.

Keywords: monetary policy, Taylor rule, regime switching
JEL Classification: E43, E58, C34

1. Introduction

After the severe hit of 2001 crisis, The Central Bank of Republic of Turkey (CBRT) has become independent with the new central bank law on May 25, 2001. The newly adopted monetary policy is characterized by flexible exchange rates and inflation targeting regime. Price stability was declared to be the primary objective of the CBRT. This policy move was quite consistent with the conditions of the time. At that time, restraining inflation alone was thought to be sufficient to maintain macroeconomic stability. Between 2002 and 2005, CBRT targeted inflation implicitly which may be considered as a transition period. The target drawn by the monetary authority in 2002 was to lower the inflation to 35% in 2002, 20% in 2003, 12% in 2004 and 8% in 2005 (Kara, 2008). At the end of the program, realizations were well above the expectations and unpredictably successful. The annual inflation remained below the targeted inflation rate each and every year. The inflation rate, which was 68 % at the end

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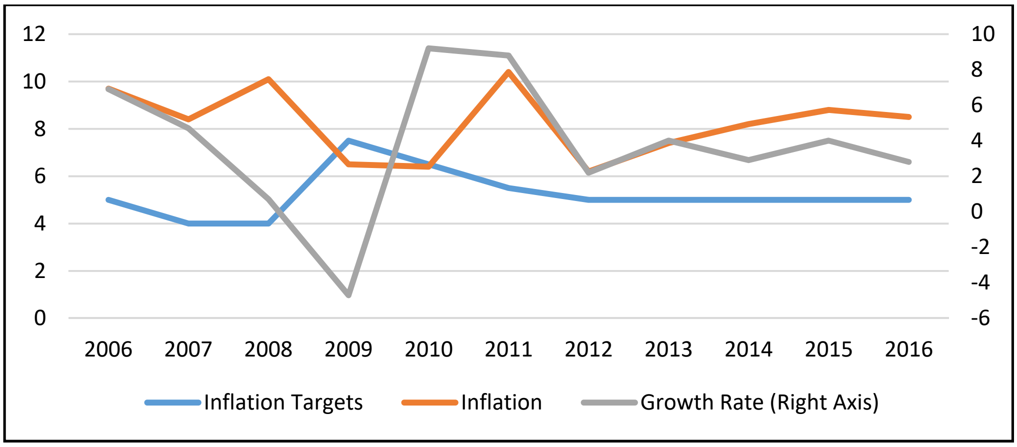
of 2001, fell to 7.7 % at the end of 2005. In the same period, fall in the inflation was accompanied by a strikingly high GDP growth rate. The average GDP growth rate reached 7.7% including the year 2006 (Gürkaynak *et al.*, 2015).

Figure 1

Inflation Targets, Inflation, and GDP Growth Rates in Turkey 2006-2016



Source: Author's calculations based on data from Central Bank of Republic of Turkey, CBRT.

As of 2006, full-fledged inflation targeting regime period has officially begun in Turkey. Figure 1 presents the inflation, inflation targets, and GDP growth rates in Turkey after the explicit inflation targeting regime was implemented. As shown in Figure 1, the inflation rate has remained on an average of eight percent (8.30) between 2006Q1 and 2016Q4 period. This inflation rate can be interpreted as a relatively low considering the history of Turkish economy that has 2-3-digit inflation figures earlier. However, it appears to be very high considering the CBRT's inflation targets, which is 5.22 on average for the 2006-2016 period. On the other hand, in 2006 Turkey has also started to witness a slowdown in its GDP growth rate. This slowdown reached to its trough in 2008 when the effects of the global financial crisis were felt severely in Turkey. The effects of the crisis are overtaken by the high growth rates in 2010 and 2011, and the long-term growth trend is observed to range around 3 % on average in the near future.

This story tells us that the post-2001 monetary policy cannot be evaluated in a holistic approach. Gürkaynak *et al.* (2015) argue that there exists a structural break in monetary policy conduction in the year 2009, where pre-2009 rules strongly responsive for controlling inflation, post-2010 rules that they do not react to rising inflation.[4] Özatay (2011) states that the Turkish economy has begun implementing a new monetary policy aimed at providing financial stability since 2010. This new approach is aimed to create a framework that will increase the durability threshold of the economy against the fragilities caused by external balance, credit expansion and capital flows.

From monetary policy point of view, there exists a significant shift in CBRT's objectives along with the overall shift in the global financial system following global financial crisis. We argue that Central Bank's incentives while determining the interest rate substantially changed after

[4] *Gürkaynak* et al. *(2015).*

2009 as many developed and developing countries. These issues make it harder to estimate a stable model of monetary policy. The use of linear models to analyze macroeconomic variables over time may not yield reliable results due to the break in time series caused by these shocks. Coefficients of a linear Taylor rule may be misleading in such an environment. For this reason, we estimate Taylor rule using the Markov Switching model that was developed by Hamilton (1989,1994) which considers the problems of structural breaks, asymmetries and nonlinearities in the time series.

This paper aims to analyze the asymmetric characteristics of monetary policy in Turkey within the frame of alternative Taylor rules during the 2003-2017 period. A major contribution of this paper is that policy regimes are chosen endogenously by using Markov regime switching methods. In order to explain the state-contingent nature of the CBRT's monetary policy, the Taylor rule is enhanced with parameters depending on two states governed by a Markov switching process. An attractive feature of Markov switching models is that no restrictions regarding the size, sign, or the state at a particular point in time have to be imposed on the parameters in estimation but are all determined by the data. To the best of our knowledge, this is the first study that examines Taylor rule in Turkey that takes exchange rates into consideration by using Markov Switching framework.

The main findings indicate that CBRT's monetary policy operated under two different regimes over the 2003-2017 period: high-interest rate regime and low-interest rate regime. There exists a sharp transition breakpoint between the two regimes in the year 2009. Roughly, pre-2009 period is shaped by high-interest rates and in post-2009 period low-interest rates prevail. The model estimates reveal that during the low regime more emphasis has been attributed to the output gap. However, the emphasis on the inflation has changed only slightly between the low-regime and the high-regime. Another important finding is that the nominal exchange rates, represented here as a feature of the small open economy, has a significant impact on CBRT's policy rule over the sample period.

The remainder of this paper is organized as follows. Section 2 briefly summarizes the previous studies on the Taylor rule. Section 3 discusses the theoretical model followed by the illustration of estimation methodology in Section 4. The data and the results are presented in Sections 5 and 6, respectively. Finally, Section 7 concludes.

2. Literature Review

Since the 1990s, as many countries have performed inflation targeting, the credibility of monetary policies has come into prominence. This leads to a considerable increase in the number of studies examining monetary policy rules all over the world. This field of research has been progressed by the theoretical contributions of Clarida *et al.* (1998, 1999, 2000), Svensson (2003), Woodford (2003). In these studies, the reaction function of a central bank is estimated and the variables by which the short-term interest rates are determined are investigated (Clarida ve Gertler, 1997; Judd ve Rudebusch, 1998).

Especially since the end of the 1990's, many studies in the literature deal with different time periods for both developed and developing countries using different econometric methods (Orphanides, 2001; English *et al.,* 2002; Huston and Spencer, 2005; Sauer and Sturm, 2007; Cukierman and Muscatelli, 2008; Choi and Wen, 2010). These studies have considered other financial variables, mainly exchange rate, besides inflation and output gap variables under open and closed economy assumptions (Dolado, 2005; Aizenman *et al*., 2011). Ball (1999), Svensson (2000), and Batını *et al.* (2003) generated the theoretical foundation of the model that takes the exchange rate's role into consideration in the reaction function of

Central Bank. Nevertheless, Ball (1999), and Batını *et al.* (2003) emphasize that the importance attributed to exchange rate should be noticeably smaller than that attributed to inflation and output gap. On the other hand, there exist few studies that show Taylor rules are being performed in neither developed nor developing countries (Ball and Sharidan, 2003; Österholm, 2005).

The number of studies on Taylor Rule for to the Turkish economy has been increasing in the last decade. Most of these consist of studies on the validity of the Taylor rule in Turkey. Berument and Taşçı (2004), Yazgan and Yılmazkuday (2007), Aklan and Nargelecekenler (2008), Onur (2008), Çağlayan and Astar (2010), Omay and Hasanov (2010), Gözgör (2012), Demirbaş and Kaya (2012), Ardor and Varlık (2014) verified the use of Taylor by employing different econometric methods over different time periods. On the other hand, some papers didn't find any significant findings on the validity of Taylor rule in Turkey. Kesriyeli and Cihan (1998) state use of Taylor is more appropriate for countries with the low inflation rate and balanced growth. This implies that this type of monetary policy is not suitable for countries that suffer from persistent inflation, such as Turkey. Us (2004, 2007), Çağlayan (2005), Erdal and Güloğlu (2005) found that the implementation of monetary policy didn't show Taylor rule characteristics in determining short-term interest rates. Erdem and Kayhan (2011) tests the Taylor rule in Turkish economy in two sub-periods in accordance with the governors of the CBRT: Sureyya Serdengeçti and Durmuş Yılmaz, respectively. Their findings reveal that while the in the period of Serdengeçti Taylor rule was not followed properly, the period of Yılmaz was shaped by it. Yağcıbaşı and Yıldırım (2017) evaluate the welfare consequences of the implementation of alternative monetary policies, which are based on different Taylor coefficients in a DSGE framework. Their findings explain that welfare losses are likely to be smaller if the monetary authority pursues a strict price stability instead of output stabilization. However, a welfare improvement may be possible by attempting to stabilize output in the case of a demand shock.

Recently, many studies examining the function of the Taylor rule in the conduction of the monetary policy have increasingly incorporated the exchange rate into Taylor's rule. Lebe and Bayat (2011), Yapraklı (2011), Uslu and Özçam (2014), Çevik and Pazarlıoğlu (2014), Pehlivanoğlu (2014), Albayrak ve Abdioğlu (2015), Bal *et al.* (2016) extended the Taylor rule by taking the exchange rate into account in the policy reaction function. In addition to including exchange rates into the reaction function, Bulut (2017) investigates the reaction function of Central Bank to fluctuations in asset prices after the global crisis in Turkey. His findings indicate that while the stock market index gap has been found statistically insignificant, exchange rate gap has significant contributions on the interest rate adjustments.

3. Theoretical Background

According to Taylor (1993, 1999), monetary policy in the United States is roughly determined by an interest rate rule that responds to the deviation of output from its potential and deviation of inflation from Fed's announced target. Since then, the rule has attracted considerable attention. It has been tested empirically over many different sample countries over different time periods. Taylor (1999) shows that the benchmark rule describes the US monetary policy successfully and further argues that "the rule is worth adopting as a principle of behavior". Furthermore, Woodford (2001) states that the rule can be used as a "prescription for desirable monetary policy." The original Taylor rule can be expressed as follows:

$$r_t = \pi_t + g\, y_t + h(\pi_t - \pi^*) + r^r \quad (1)$$

where: the variable r_t stands for the short-term interest rate at time t, π_t is the inflation rate at time t, y_t is the percentage deviation of real output from the trend, $\pi^*$is the target inflation rate and r^r is a constant which. Parameters g and h stand for the responsiveness of interest rate to output gap and deviation of inflation from its target, respectively. The corresponding intercept is r^r-h π^*, slope coefficient for inflation is 1+h and slope coefficient for output gap is g. From a theoretical standpoint, we expect both slope coefficients to be positive. However, the magnitude of these coefficients depends on the sample characteristics.

Since the 2008 crisis, almost all countries, especially developing countries tend to control excessive exchange rate volatility. However, this exchange rate policy has raised concerns on how this policy might affect the monetary policy of these economies. Taylor (2001) indicates that exchange rate plays a significant role in the transmission mechanism through arbitrage equations relating domestic interest rate to the interest rates in the world economy as well as in terms of trade. For instance, a significant appreciation of one country's currency gives rise to an upward pressure on interest rates. Hence, although inflation and the output gap are the Central Bank's primary targets, it also has to take the exchange rate into account while implementing monetary policy. Studies like Ball (1999), Svensson (2000) and Taylor (1999) among others started to incorporate exchange rates into Taylor rule. Such a rule can be expressed as follows:

$$r_t = \pi_t + g\, y_t + h(\pi_t - \pi^*) + f\, er_t + r^r \qquad (2)$$

where: er_t represents the nominal exchange rates and f is the parameter governing sensitivity of interest rate to exchange rate. Interpretations for the variables in the benchmark model holds for the augmented model as well. The only inclusion is the exchange rate variable. There is no consensus on the expected sign of this variable. However, conventional opinion on this issue is a positive realization of f coefficient in case of an appreciation in exchange rates.

4. Methodology and Empirical Model

Macroeconomic time series there may be shifts in the characteristics of the series as the sample period gets longer. This change in their behavior may be permanent due to some structural changes or temporary due to some crisis, wars or other phenomena. These shifts in the series made it necessary to use models that incorporate parameter variation.

In regime-switching models, parameters are allowed to change in each finite number of regimes. It is possible to classify regime switching models into two categories based on the assumption regarding the switching mechanism of the state variable. In threshold models, the regimes are determined by the comparison of an unobserved threshold and the level of observed variables. On the other hand, in Markov-Switching models, regime shifts are governed by a Markov-chain. The Markov Switching models brought into the econometrics literature by Goldfeld and Quandt (1973), Cosslett and Lee (1985), and Hamilton (1989). Let

$$y_t = \alpha_{s_t} + x_t^{'}\beta_{s_t} + \epsilon_t \qquad (3)$$

where: ϵ_t *i.i.d.* N$(0,\sigma^2_{\epsilon,s_t})$. Here, s_t is the random variable that governs the regime switching process by means of a Markov chain. Given the past states $S_0, S_1, S_2, \dots S_{t-1}$, the conditional distribution of any future state S_{t+1} is only dependent on the present state. Transition probability the probability of state j given that the preceding state is i, is denoted as p_{ij} and can be described as follows.[4]

$$P_{ij} = \{s_t = j|s_{t-1} = i\} = p\{s_t = j|s_{t-1} = i,\, s_{t-2} = k\ldots\} \qquad (4)$$

Note that $p_{i1} + p_{i2} + \cdots + p_{iN} = 1$. The matrix P presents the transition probabilities in matrix notation for convenience.

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{N1} \\ p_{12} & p_{22} & & p_{N2} \\ \vdots & & \ddots & \vdots \\ P_{1N} & p_{2N} & \cdots & p_{NN} \end{bmatrix}$$

In the estimation process of Equation (3) we use expectation maximization algorithm proposed by Hamilton (1994) and Krolzig (1997). Initially, unobserved state variables (st) are estimated by means of the smoothed transition probabilities which are computed by means of BHLK (Baum-Hamilton-Lee-Kim) filtering of conditional probabilities. Then, unknown parameter vector is obtained by first-order conditions. Finally, conditional regime switching probabilities are replaced with smoothed probabilities.[5]

Applying Markov regime switching model to Taylor rule yields the following model to be estimated:

$$i_t = \alpha_{s_t} + x_t' \beta_{s_t} + \epsilon_t \qquad (5)$$

where: x_t represents the vector containing exogenous variables, namely output gap and inflation for benchmark Taylor rule and output gap, inflation and exchange rate for the augmented Taylor rule. α_{s_t} is the matrix for intercept coefficients for each state, β_{s_t} is the matrix of slope coefficients and ϵ_t is the vector of disturbances for each state. On operational ground, we estimate all variables contemporaneously. Literature on Taylor rule has alternative specifications such as forward-looking rules and backward-looking rules. But according to our survey on literature, contemporaneous Taylor rules provide the best fit to the data (Duffee, (2013), Branch, (2011)). According to Islam (2011), "forecast-based rules can incorporate comprehensive and up-to-date macroeconomic information and can account for transmission lags and other structural features … some researchers concluded that it is not clear if forward-looking estimates have any advantage over contemporaneous or backward-looking versions of the rule". Since we do not intend to make forecast or constructing a policy, but to observe the fit of the rule to the Turkish data, and the potential gains of using forward-looking rule is unclear we preferred using original Taylor rule.

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[4] Hamilton, 1994.

[5] For further information about estimation process, one may refer to Hamilton (1994) and Krolzig (1997).

5. Data

We use monthly data from January 2003 to July 2017 for Turkey[6]. A total of four variables were used for the analysis. Data on these variables have been obtained from the CBRT and The Banks Association of Turkey (BAT) databases.

Table 1

Data and Variables

Variable	Data	Source
Interest rates	Libor	BAT
Output gap	IPI	CBRT
Inflation	CPI	CBRT
Nominal exchange rate	US Dollar	CBRT

For the interest rate, we used Libor weekly interest rate which is commonly used as Central Bank policy tool in the literature (Alp *et al*., 2010; Gürkaynak *et al*., 2015). For the output gap, since Gross Domestic Product data is not present on a monthly basis, we used Industrial Production Index (IPI) as a proxy. Then, Hodrick-Prescott (HP) filtering is applied to the natural logarithm of IPI. Finally, the output gap is calculated by taking the difference between the log of IPI and trend series obtained from HP filter. Inflation is obtained from seasonally adjusted Consumer Price Index (CPI). Finally, the nominal exchange rate is taken as US dollar. All data is in the form of the natural logarithm excluding output gap[7].

6. Empirical Findings

In this study, two separate models are estimated[8]. The first is the benchmark model of original Taylor rule (Eq 1). The latter is the augmented model, which is the extension of original Taylor rule that also includes exchange rates (Eq 2). In both models, statistical tests lead to the selection of 2 regimes: high-interest rate and low-interest rate. Regime 0 (hereafter low regime) coincides with the period during which the interest rates are lower than average while regime 1 (hereafter high regime) coincides with the period in which the CBRT conducted monetary policy under high-interest rates. According to our calculations, in the benchmark model mean interest rate is 2.832 for the high regime and 2.105 for the low regime. In a similar manner, in the case of the augmented model mean interest rates are 2.834 and 2.130 for the high and the low regime, respectively. This finding supports our regime classification.

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[6] *As of 2002 CBRT has moved to inflation targeting framework and follow a Taylor-type reaction function. Due to the data restrictions we started the analysis from 2003.*

[7] *Furthermore, Tsay and Keenan linearity tests were applied to the series. Findings revealed that the series are not linear. This proves another motivation to apply nonlinear analysis.*

[8] *Before conducting regime switching approach, we first estimate a linear Taylor rule using Ordinary Least Squares (OLS) methods. The findings reveal the aggressive response to inflation and insignificant coefficient for output gap under both benchmark and augmented Taylor rules. Furthermore, Taylor rule's response to exchange rate is negative and statistically significant. We also estimated Taylor rule with exogenous structural break. The break date determined by Chow break test is 2010:9. According to findings, both benchmark and augmented model's coefficients are found to be statistically significant, which is consistent with the related literature.*

The Smoothed probabilities of Markov regime process that govern the coefficient of model and variance switching is presented in Figure A1 and A2. From 2003, the monetary policy of Turkey is in the first regime, which is characterized by a high-interest rate. This high-interest rate regime lasts until the tenth month of 2009, which is 81 months in total. Then monetary policy regime switches into the low-interest rate regimes, which span from 2009 (11) to 2014 (12) add up to a total of 62 months. Later, together with increasing interest rates, it returns to the high-interest rate regime until 2016 (5). After that time, monetary policy in Turkey again switches into low-interest rate regime as from 2016 (7) to the end of the sample.

Table 2

Estimation Results of the Benchmark Model

	Coefficients	Std. Deviation	t statistics	Probability
Intercept (0)	0.779	0.232	3.35	0.001
Intercept (1)	0.904	1.262	7.17	0.000
Output gap (0)	2.538	1.109	2.29	0.023
Output gap (1)	0.557	0.430	1.29	0.197
Inflation (0)	0.636	0.106	5.97	0.000
Inflation (1)	0.850	0.518	16.4	0.000
Sigma	0.184	0.010	18.1	0.000

The findings obtained from the estimation of the benchmark model are presented in Table 2. Except for the coefficient for output gap at the high regime, all parameters are statistically significant and in line with economic intuition. In both regimes, CBRT's reaction to inflation is positive and statistically significant. This reaction is stronger in high regime (0.850) compared to the low regime (0.636). This means that CBRT pays more attention to change in inflation in the high regime in comparison to the low regime. Regarding the output gap, despite having a positive value, the coefficient is statistically insignificant in the high regime. CBRT does not react to output gap at the high regime. However, after 2010, when the low regime prevails, the reaction becomes significant and its effect is 5 times stronger in the low regime than in the high regime (2.538 and 0.557, respectively). One may see that many developed countries have changed their monetary policy framework after the 2008 global financial crisis. As one of the examples of that, Turkey introduced a new monetary policy framework that is a combination of traditional inflation targeting framework, financial stability and macro-prudential policies. After the severe trough of 2009, Turkish economy started to implement a new monetary policy framework that considers high and sustained economic growth by dealing with external shocks. Therefore, interest rate does not react to the output gap in the regime before 2009 while it reacts more aggressively after 2010. Note that at the post-2009 period in which the high regime prevails the reaction to output gap is much stronger than the reaction to inflation which means CBRT put more emphasize to output gap stabilization than to inflation stabilization.

Table 3 demonstrates the transition probabilities for the benchmark model and augmented models. As mentioned earlier, transition probability p_{ij} denotes that probability of the economy will be in regime j given that at time t economy is in regime i. Note that as p_{ii} gets closer to 1, the regime i is interpreted to be last longer. Findings indicate that both regimes are quite persistent over time. The probability of remaining in regime 0 is 0.986 while the probability of remaining in regime 1 is 0.978.

Table 3

Transition Matrix for Benchmark and Augmented Model

	Benchmark Model		Augmented Model	
	Regime 0,t	Regime 1,t	Regime 0,t	Regime 1,t
Regime 0, t+1	0.986	0.021	0.987	0.010
Regime 1, t+1	0.013	0.978	0.013	0.989

The following equations show how long is the average duration in each regime when the estimated probabilities of transition are given: $\frac{1}{1\text{-}p_{11}}$ and $\frac{1}{1-p_{00}}$. Furthermore, one may refer to the Table 4 to observe how long the low and high regimes last and corresponding periods of each regime under both models.

Table 4

Duration Matrix for Benchmark and Augmented Model

Benchmark Model			Augmented Model		
	Number of months	Average Prob.		Number of months	Average Prob.
Regime 0			Regime 0		
2009(11)- 2014(12)	62	0.993	2009(11)-2016(5)	79	0.964
2016(6)-2017(7)	14	0.982			
Regime 1			Regime 1		
2003(2)- 2009(10)	81	0.993	2003(2)-2009(10)	81	0.996
2015(1)-2016(5)	17	0.887	2016(6)-2017(7)	14	0.917
Regime 0	Total of 76 months with an average duration of 38 months.		Regime 0	Total of 79 months with an average duration of 79 months	
Regime 1	Total of 98 months with an average duration of 49 months.		Regime 1	Total of 95 months with an average duration of 48 months	

Table 5 presents the estimation results of Markov Regime Switching Model for the augmented model. As in the benchmark model, all the coefficients that are estimated in augmented Taylor rule are statistically significant except the output gap in the high regime. Inflation rate's coefficient under the high regime is significant and considerably larger than it is under the low regime (0.816 and 0.370, respectively). It is important to note that high regime is associated with larger coefficient on inflation compared to the low regime. This can be interpreted as an indication of CBRT's weaker response to inflation after 2010 period. Taylor principle states that an increase in inflation by one percentage point should prompt the central bank to raise the nominal interest rate by more than one percentage point. Our findings suggest that the coefficient of inflation is less than 1% under both benchmark and augmented model. That implies that the Taylor principle is not satisfied during the period investigated in Turkey. Which is consistent with our hypothesis that CB after 2009 crisis.

Table 5

Estimation Results of the Augmented Model with Exchange Rates

	Coefficients	Std. Deviation	t statistics	Probability
Intercept (0)	0.846	0.203	4.17	0.000
Intercept (1)	1.196	0.100	11.9	0.000
Output gap (0)	2.853	1.023	2.79	0.006
Output gap (1)	0.115	0.358	0.322	0.748
Inflation (0)	0.370	0.095	3.88	0.000
Inflation (1)	0.816	0.041	19.5	0.000
Exchange Rate(0)	0.757	0.082	18.5	0.000
Exchange Rate(1)	-0.514	0.054	-9.51	0.000
Sigma	0.151	0.008	18.5	0.000

For the high regime, inflation and exchange rate coefficients are statistically significant whereas the output gap coefficient is not[9]. So, CBRT sets the instrument rate by considering the movements of the exchange rates and inflation only and disregards the movements of the output gap in the high regime. As in the benchmark model, under the low regime period, the response to output gap seems to be about 9-10 times higher than the response to inflation. Under the high regime, the response to inflation is almost three times stronger compared to the inflation coefficient under the low regime. The positive coefficient on nominal exchange rate (in low regime) means that depreciation of the currency leads to an increase in interest rates. On the contrary, the coefficient of the exchange rate in high regime is found to be negative. This result shows that in case of a depreciation, the central bank decreased interest rates rather than bringing it at a stable rate. This negative coefficient may represent an attempt to encourage exports, rather than to smooth exchange rates or control inflation (Hutchison et al., 2013).

7. Conclusions

This study makes a contribution to the increasing literature on the nonlinear investigation of monetary policy rules. Since the reflections of dynamic economic circumstances on monetary policy can be examined with endogenously determined dates of the changes, Markov regime switching model serves as an attractive tool.

Our primary question is whether CBRT's monetary policy, which increasingly described by policymakers and academicians as highly discretionary, may be described by simple policy rules. For this reason, in this paper, monetary policy reaction function for Turkey has been estimated using Markov regime switching model. The findings show that CBRT reacts to the inflation, output gap, and nominal exchange rate as predicted by the theory.

The findings show that the monetary policy approximately in the last 15 years has been conducted under two different regimes, which we denote as high-interest rate and low-interest rate regimes. High regime represents the high-interest rates while the low regime is associated with a low-interest rates period. According to benchmark model, low regime takes place between 2009(11)-2014(12) and 2016(6)-2017(7) period adding up to a total of 76

[9] Second regime in the study represents a period of high interest rates, which corresponds to the period of 2003-2009. During this period, the Central Bank aimed to strictly reduce inflation and its inflation targeting was insensitive to changes in the output gap. Priority was to hit the inflation target.

months with an average duration of 38 months, while high regime prevails at 2003(2)-2009(10) and 2015(1)-2016(5) with an average duration of 49 months. Augmented model's (i.e. extended with exchange rate) regime durations also follow a similar pattern. However, under this specification low regime consists of only one (2009(11)-2016(5)) period. In other words, no switching back to the high regime can be observed after 2014. While CBRT is more sensitive to the deviations from the inflation during the high regime (2003-2009), this sensitivity began to decrease after 2009 (10). Moreover, it follows that the sensitivity of the CBRT to the output gap before 2009 is insignificant, but this sensitivity has increased considerably after 2009 (10). Shortly, empirical findings show that along with inflation, the output gap played an important role in determining the short-term interest rate (in high regime).

The findings also reveal that the external factors, which they determine the value of the nominal exchange rate, affect the CBRT's monetary policy considerably within the sample examined. This situation existed shows that the CBRT is reacting in a traditional way by increasing the nominal interest rates against the depreciation of the exchange rate. (i.e. when low-interest rate regime prevails). However, the negative sign under the high regime can be explained by CRBT's aims to depreciate the exchange rate to encourage exports by lowering nominal interest rates. Moreover, note that at the post-2010 period, in which the high regime prevails, the reaction to output gap is much stronger than the reaction to inflation which means CBRT values output gap stabilization more than inflation stabilization.

We only considered exchange rate to represent a small open economy characteristic of Turkey better. However, for further research one may consider incorporating other financial variables such as house and asset prices or credit gaps to fully capture the impacts from the rest of the world on domestic monetary policy as well as a macro-prudential tool.

References

Adanur-Aklan, N., Nargeleçekenler, M., 2008. The Taylor Rule: An Assessment of Turkish Experience. Ankara University, *Faculty of Political Science Journal*, 63(2), pp.22-41.

Aizenman, J., Hutchison, M., Noy, I., 2011. Inflation Targeting and Real Exchange Rates in Emerging Markets. *World Development*, 2011, 39(5), pp.712-724. doi: 10.3386/w14561

Albayrak, N., Abdioğlu, Z., 2014. Estimating Backward and Forward-Looking Monetary Policy Reaction Functions: Taylor Rule. Suleyman Demirel University *The Journal of Faculty of Economics and Administrative Sciences*, 20(4), pp.141-163.

Alp, H. *et al*., 2010. Türkiye'de Piyasa Göstergelerinden Para Politikası Beklentilerinin Ölçülmesi. *İktisat İşletme ve Finans*, 25(295), pp.21-45

Ardor, H.N. and Varlık, S., 2014. Estimation of New Keynesian Monetary Policy Reaction Function: Availability of Taylor Rule, McCallum Rule and Hybrid Taylor-McCallum Rule in Turkish Economy. *Ekonomik Yaklaşım,* 24(89), pp.45-71. doi:10.5455/ey.35302

Bal, H., Tanrıöver, B. and Erdoğan, E., 2016. Determining the Policy Interest Rates of the Central Bank within Framework Taylor Rule: Stochastic Trend Approach. *International Journal of Academic Value Studies*, 2(6), pp.95-106.

Ball, L.M., 1999. Policy Rules for Open Economies. In *Monetary Policy Rules*. pp.127-156. University of Chicago Press.

Ball, L. and Sheridan, N., 2003. Does Inflation Targeting Matter?. *NBER Working Paper*, No. 9577.

Batini, N., Harrison, R. and Millard, S.P., 2003. Monetary Policy Rules for an Open Economy. *Journal of Economic Dynamics and Control*, 27(11-12), pp.2059-2094. https://doi.org/10.1016/S0165-1889(02)00116-1

Berumenti H. and Taşçı, H., 2004. Monetary Policy Rules in Practice: Evidence from Turkey. *International Journal of Finance and Economics*, 9, pp.33-38. doi: 10.1002/ijfe.219

Branch, W.A.and Evans, G.W., 2011. Monetary policy and heterogeneous expectations. Economic Theory, 47(2-3), pp.365-393.

Bulut, Ü., 2017. Monetary Policy and Asset Prices in the Period Following the Global Crisis: The Case of Turkey. Eskişehir Osmangazi Üniversitesi *İİBF Dergisi*. 12(1), pp.13-30.

Choi, G.W. and Wen, Y., 2010. Dissecting Taylor Rules in a Structural VAR. *The Federal Reserve Bank of St. Louis Working Paper Series*, 2010-005A, pp.1-34.

Clarida, R. and Gertler, M., 1997. How the Bundesbank Conducts Monetary Policy. In: Romer, C. D. and D. H. Romer, eds. *Reducing Inflation: Motivation and Strategy*, pp.363-412. Chicago: University of Chicago Press.

Clarida, R., Gali, J. and Gertler, M., 1998. Monetary Policy Rules in Practice: Some International Evidence. *European Economic Review*, 42(6), pp.1033- 1068.

Clarida, R., Gali, J. and Gertler, M., 1999. The Science of Monetary Policy: A new Keynesian Perspective. *Journal of Economic Literature*, 37(4), pp.661–707.

Clarida, R., Gali, J. and Gertler, M., 2000. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *Quarterly Journal of Economics,* 115(1), pp.147-180. https://doi.org/10.1162/003355300554692.

Cosslett, S.R. and Lee, L.F., 1985. Serial Correlation in Latent Discrete Variable Models. *Journal of Econometrics*, 27(1), pp.79-97.

Cukierman, A. and Muscatelli, A., 2008. Nonlinear Taylor Rules and Asymmetric Preferences in Central Banking: Evidence from the United Kingdom and the United States. *The B E Journal of Macroeconomics,* 8(1) . https://doi.org/10.2202/1935-1690.1488

Çaglayan, E., 2005. Türkiye'de Taylor Kuralının Geçerliliğinin Ekonometrik Analizi. Marmara Üniversitesi *İİBF Dergisi*, 20, pp.379-392.

Çağlayan, E. and Astar, M., 2010. Taylor Rule: Is it an Applicable Guide for Inflation Targeting Countries?. *Journal of Money, Investment and Banking*, 18, pp.56-67.

Çevik, N.K. and Pazarlıoğlu, V., 2014. The Structure of Monetary Policy and Monetary Rule in Turkey during the Period 1990-2013. *Balkan Journal of Social Sciences*, 3(6), pp.4-23.

Demirbaş, E. and Kaya, M.V., 2012. Testing the Validity of Taylor Principle for Turkey from a Different Perspective. *AIBU Journal of Social Sciences*, 20, pp.81-110.

Dolado, J., Maria-Dolores, R. and Naveira M., 2005. Are Monetary-Policy Reaction Functions Asymmetric?: The Role of Nonlinearity in the Phillips Curve. *European Economic Review*, 49(2), pp.485-503. https://doi.org/10.1016/S0014-2921(03)00032-1

Duffee, G.R., 2013. Bond pricing and the macroeconomy. In: *Handbook of the Economics of Finance,* Vol. 2, pp. 907-967. Elsevier.

Erdem, E. and Kayhan, S., 2011. The Taylor Rule in Estimating the Performance of Inflation Targeting Programs: The Case of Turkey. *Global Economy Journal*, 11(1), pp.1-15.
English, W.B., Nelsoni, W.R. and Sack, B.P., 2002. Interpreting the Significance of the Lagged Interest Rate in Estimated Monetary Policy Rules. Division of Monetary Affairs Board of Governors of the Federal Reserve System, 24, pp.1-27.
Erdal, F. and Güloğlu, B., 2005. Modelling Real Exchange Rate Behavior with the Taylor Rule: An Empirical Analysis. Proc. The International Conference on Policy Modeling, EcoMod, Istanbul.
Goldfeld, S.M. and Quandt, R.E., 1973. A Markov Model for Switching Regressions. *Journal of Econometrics*, 1(1), pp.3-15. https://doi.org/10.1016/0304-4076(73)90002-X
Gözgör, G., 2012. Inflation Targeting and Monetary Policy Rules: Further Evidence from the Case of Turkey. *Journal of Applied Finance and Banking*, 2(5), pp.127-136.
Gürkaynak, R.S., Kantur, Z., Taş, M.A. and Yıldırım-Karaman, S., 2015. Monetary Policy in Turkey after Central Bank Independence. *İktisat İşletme ve Finans*, 30(356), pp.9-38.
Hamilton, J.D., 1989. A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle. *Econometrica: Journal of the Econometric Society*, pp.357-384.
Hamilton, J.D. and Susmel, R., 1994. Autoregressive Conditional Heteroskedasticity and Changes in Regime. *Journal of Econometrics*, 64(1), pp.307-333. https://doi.org/10.1016/0304-4076(94)90067-1
Huston, J.H. and Spencer, R.. 2005. International Monetary Policy: A Global Taylor Rule. *International Advances in Economic Research*, 11(2), pp.125-134. DOI: 10.1007/s11294-005-3010-0
Hutchison, M.M., Sungupta, R. and Singh, N., 2013. Dove or Hawk? Characterizing Monetary Policy Regime Switches in India. *Emerging Market Reviews*, 16, pp.183-202. http://dx.doi.org/10.1016/j.ememar.2013.05.005
Islam, M.S., 2011. Taylor Rule-based Monetary Policy for Developing Economies-A case Study with Malaysia. *International Review of Business Research Papers*, 7(1), pp.134-149.
Judd, J.P. and Rudebusch G.D., 1998. Taylor's Rule and the Fed: 1970-1997. *Federal Reserve Bank of San Francisco, Economic Review*, (3), pp.3-16.
Kara, A.H., 2008. Turkish Experience with Implicit Inflation Targeting. *Central Bank Review*, 8(1), pp.1-16.
Kesriyeli, M. and Yalçın, C., 1998. Taylor Kuralı ve Uygulaması Üzerine Bir Not. TCMB Araştırma Genel Müdürlüğü Tartışma Tebliği, No: 9802.
Krolzig, H.M., 1997. Markov-switching Vector Autoregression. Lecture Notes in Economic and Mathematical Systems.
Lebe, F. Bayat, T. (2011). Taylor Rule: A Vector Autoregressive Model Analysis for Turkey, *Ege Academic Review*, 11, pp.95-112.
Omay, T. and Hasanov, M., 2010. Türkiye için Reaksiyon Fonksiyonunun Doğrusal Olmayan Modelle Tahmin Edilmesi. Çankaya University *Journal of Humanities and Social Sciences,* 7(2), pp. 467-490.
Onur, S., 2008. A Model Attempt on the Relation of Interest Rates and Inflation in Turkey (1980-2005). *Journal of Qafqaz University*, 24, pp.123- 145.

Orphanides, A., 2001. Monetary Policy Rules Based on Real-Time Data. *American Economic Review*, 91(4), pp.964-985. DOI: 10.1257/aer.91.4.964.

Österholm, P., 2005. The Taylor Rule: A Spurious Regression?. *Bulletin of Economic Research*, 57(3), pp.217-247. doi: 10.1111/j.0307-3378.2005.01220.x

Özatay, F., 2015. The New Monetary Policy of the Central Bank: Two Targets-Three Intermediate Targets- Three Tools. *İktisat İşletme ve Finans*, 26(302), pp.27-43.

Pehlivanoğlu, F., 2014. The Estimation of Taylor Type Interest Rate Reaction's Function in The Frame of Optimal Monetary Policy: The Case of Turkey. *The Journal of Knowledge Economy and Knowledge Management.* 9(1), pp.116-126.

Sauer, S. and Sturm, J.E., 2007. Using Taylor Rules to Understand European Central Bank Monetary Policy. *German Economic Review*, August, 8(3). pp.375-398. doi: 10.1111/j.1468-0475.2007.00413.x

Svensson, L.E., 2000. How should Monetary Policy be conducted in an Era of Price Stability? *NBER* No. w7516.

Svensson, L.E., 2003. What is wrong with Taylor rules? Using judgment in monetary policy through targeting rules. *Journal of Economic Literature*, 41, pp.426–77.

Taylor, J.B., 1993. Discretion Versus Policy Rules in Practice. Carnegie-Rochester Conference Series on Public Policy. 39.

Taylor, J.B., 1993 The Use of the New Macro Econometrics for Policy Formulation. *American Economic Review*, American Economic Association, 83(2), pp.300-305

Taylor, J.B., 1999. A Historical Analysis of Monetary Policy Rules. In *Monetary Policy Rules*, pp.319-348. University of Chicago Press.

Taylor, J.B., 2001. The Role of the Exchange Rate in Monetary-Policy Rules. *American Economic Review*, 91(2). pp.263-267. doi: 10.1257/aer.91.2.263

Us, V., 2004. Monetary Transmission Mechanism in Turkey Under the Monetary Conditions index: An Alternative Policy Rule, *Applied Economics*, 36(9). pp.967-976.

Us, V., 2007. Alternative Monetary Policy Rules in the Turkish Economy under an Inflation-Targeting Framework, *Emerging Markets Finance and Trade*, 43 (2). pp.82-101

Uslu, L. and Özçam, A., 2014. A Modified Taylor Rule for the Central Bank of Turkey: 2003-2012. KSÜ *İİBF Dergisi*, 4(1). pp.2-18.

Woodford, M., 2001. The Taylor Rule and Optimal Monetary Policy. *American Economic Review*, 91(2). pp.232-237.

Woodford, M., 2003. Optimal Interest-rate Smoothing. *Review of Economic Studies*, 70, 861–86.

Yapraklı, S. (2011). The Validity of Open Economy Monetary Policy Rule in Turkey: A Bounds Test Approach. *"IS-GUC" Industrial Relations and Human Resources Journal*, 13 (1). pp.127-142.

Yazgan, M.E. and Yılmazkuday, H., 2007. Monetary Policy Rules in Practice: Evidence from Turkey and Israel. *Applied Financial Economics*, 17, pp.1-8.

Yağcıbaşı, Ö.F. and Yıldırım, M.O., 2017. Welfare Implications of Alternative Monetary Policy Rules: A New Keynesian DSGE Model for Turkey. *Review of Economic Perspectives.*17(4). DOI: 10.1515/revecp-2017-0019

Appendix

Figure A1
The Estimated Smoothing Probabilities under Benchmark Taylor Rule

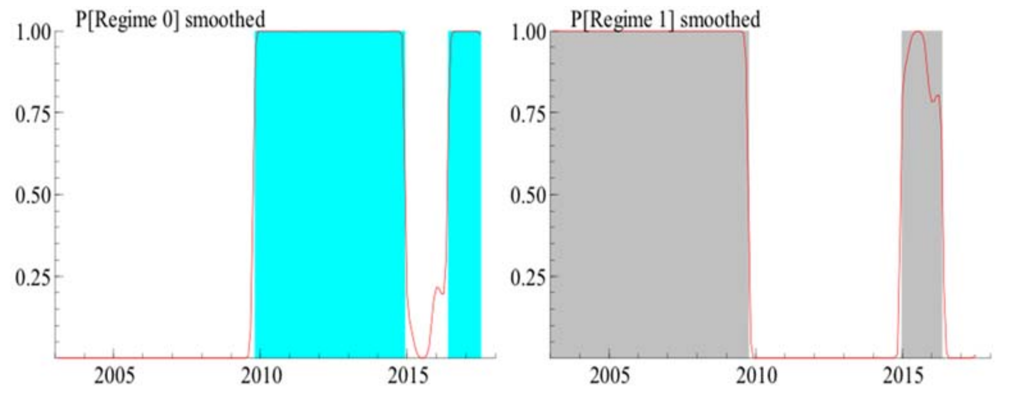

Figure A2
The Estimated Smoothing Probabilities under Augmented Taylor Rule