DE GRUYTER OPEN

UDK: 336.711(560)
DOI: 10.1515/jcbtp-2016-0005

Journal of Central Banking Theory and Practice, 2016, 1, pp. 99-111
Received: 8 July 2015; accepted: 10 August 2015

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How Far Ahead Does the Central Bank of the Republic of Turkey Look?[1]

Abstract: In monetary economics literature, there is an agreement that monetary policy has a lagged effect on inflation. As a result of this agreement, monetary policy reaction functions that include expected inflation, instead of current or lagged inflation, are established. On the other hand, there is uncertainty about how much time monetary policy needs to affect inflation. The purpose of this paper is to estimate empirically how far ahead the Central Bank of the Republic of Turkey looks. In other words, the paper examines whether the CBRT takes into consideration 12-month ahead inflation expectations or 24-month ahead inflation expectations while steering interest rates. According to the results of the paper, the CBRT considers 12-month ahead inflation expectations while steering interest rates.

Key words: The Central Bank of the Republic of Turkey, lags in monetary transmission mechanism, forward-looking reaction function.

JEL Codes: C22, E52, E58.

1. Introduction

The reaction function of a central bank shows how the central bank adjusts the main instrument of monetary policy with regard to economic events (Judd and Rudebusch, 1998). In today's world, many central banks conduct monetary policy by steering short-term/overnight interest rates not by trying to achieve the

[1] This paper was presented in Turkish on June 10-12, 2015 at EconAnadolu 2015 which was organized in Eskisehir, Turkey.

growth target in monetary base or money supply. Hence overnight interest rate has become the most important instrument of central banks. Overnight interest rates are determined through borrowing and lending operations of banks between each other on a daily basis. Central banks aim to affect long-term interest rates on credits, deposits, bonds, and thus impact aggregate demand by controlling short-term interest rates. A central bank controls short-term interest rates by determining the amount of liquidity that is supplied to banks by the central bank and/or borrowing and lending rates between the central bank and banks. Then, the reaction function of the central bank shows how it adjusts overnight interest rates in response to economic events.

Since the seminal paper of Taylor (1993), many papers have been conducted on reaction functions of central banks (see e.g., Clarida and Gertler, 1997; Judd and Rudebusch, 1998; Clarida et al., 1998, 2000; Nelson, 2000; Sutherland, 2010; Kumar, 2013). The main criticism towards Taylor (1993) is that he does not take into account that monetary policy has a lagged effect on economy. Therefore, Clarida et al. (1998) produce a reaction function considering that monetary policy affects inflation with a lag. Besides, Clarida et al. (2000) suggest a reaction function considering that monetary policy affects both inflation and output with a lag. These reaction functions are called forward-looking reaction while the equation suggested by Taylor (1993) is called the Taylor rule in monetary economics literature.

When the empirical literature is examined on the reaction function of the Central Bank of the Republic of Turkey (CBRT), it can be noticed that either the validity of the Taylor rule is investigated or the forward-looking reaction function is estimated for the CBRT (see e.g., Berument and Malatyalı, 2000; Berument and Tasci, 2004; Yazgan and Yılmazkuday, 2007; Kaytanci, 2008; Erdem and Kayhan, 2010; Gozgor, 2012). Besides, the papers that estimate the forward-looking reaction function for the CBRT examine whether the CBRT reacts to changes in the difference between the 12-month ahead expected inflation rate and the inflation target. Hence, it is implicitly assumed that the effect of monetary policy on inflation is shown up in 12 months in Turkey and the CBRT steers interest rates considering this lagged effect. This paper estimates the reaction function for the CBRT acknowledging that lags in monetary policy transmission mechanism may be greater than 12 months in Turkey. In this respect, the paper aims to examine whether the CBRT regards the 12-month ahead inflation expectations or 24-month ahead inflation expectations while steering interest rates.

The rest of the paper is as follows: Section 2 gives the Taylor rule and forward-looking reaction functions. Section 3 illustrates the model and data. Estimation methodology and findings are presented in Section 4. Section 5 concludes the paper with a summary of the main findings and some implications.

2. Taylor rule and forward-looking reaction functions

The Taylor rule was not produced as a result of a comprehensive theoretical model or intensive academic debates (Bofinger et al., 2001). The equation suggested by Taylor (1993) and known as the Taylor rule is as follows (Taylor, 1993; Judd and Rudebusch, 1998):

Equation (1):

$$r = p + 0.5y + 0.5(p-2) + 2 \tag{1}$$

where

r = federal funds rate (overnight interest rate in the US),
p = inflation rate over the previous four quarters,
y = the percent deviation of real GDP from a target.

That is,

$Y = 100(Y - Y^*)/Y^*$
Y = real GDP,
Y^* = the trend of real GDP.

Taylor (1993) did not econometrically estimate this equation and assumed that the Fed gave these weights to the deviations (Judd and Rudebusch, 1998). The main criticism towards the Taylor rule is that the rule does not take into consideration that monetary policy has a lagged effect on inflation. Thus Clarida et al. (1998) produce a reaction function which is the most commonly used in literature. This reaction function is as follows:

Equation (2):

$$i_t = \beta_0 + \beta_1 i_{t-1} + \beta_2 \Pi^e_{t+n/t} + \beta_3 x_t + \varepsilon_t \tag{2}$$

where

i_t = overnight interest rate at t period,
i_{t-1} = overnight interest rate at t-1 period,

$\Pi^e_{t+n/t}$= annual inflation rate expected for m-period ahead at t period,
x_t= output gap at t period,
ε_t= error term.

Because central banks may have a tendency to smooth interest rates, the reaction function above includes the one-period lagged value of overnight interest rates (Clarida et al., 1998). If $0 < \beta_1 < 1$, the central banks have a tendency to smooth interest rates. Interest rate smoothing is a gradual adjustment of the overnight interest rate to the expected level.

The reaction function depicted in Equation (2) includes expected inflation data and current output gap data. Clarida et al. (1998) argue that prices and wages are rigid and thus monetary policy can affect output in the short term according to their approach. On the other hand, Clarida et al. (2000) propound a new reaction function which includes expected output gap data. This reaction function is denoted in

Equation (3):

$$i_t = \beta_0 + \beta_1 i_{t-1} + \beta_2 \Pi^e_{t+n/t} + \beta_3 x^e_{t+k/t} + \varepsilon_t \tag{3}$$

where $x^e_{t+k/t}$ denotes expected output gap for k-period ahead at t period.

3. Specification of the model and data

The reaction function herein does not include the one-period lagged value of overnight interest rates as it has not been examined whether the CBRT smooths interest rates. In order to determine inflation expectations taken into consideration by the CBRT, the model incorporates both the difference between 12-month ahead expected inflation rate and inflation target and the difference between 24-month ahead expected inflation rate and inflation target. Because the CBRT does not supply expected output gap data and the accurate estimation of the current output gap by the CBRT is not reasonable, the lagged value of the output gap is included in the model. HP filter produced by Hodrick and Prescott (1997) is used to calculate the output gap. While calculating the output gap, the method used by Yazgan and Yılmazkuday (2007) is employed. Accordingly, to obtain the value of the gap at t period, the series are detrended using the data ending in t. Similarly, the series are detrended using the data ending in t+1 to obtain the value of the gap at t+1 period. This process is repeated all the way to the last value of the sample. In other words, the analysis is conducted by taking account of the gap that the CBRT might observe.

After these explanations, the reaction function that will be estimated for the CBRT is established as follows:

Equation (4):

$$i_t = \beta_0 + \beta_1(\pi^e_{t+m/t} - \pi^t_{t+m/t}) + \beta_2(\pi^e_{t+n/t} - \pi^t_{t+n/t}) + \beta_3 Y^{gap}_{t-k} + \varepsilon_t \quad (4)$$

where

i_t = overnight interest rates (overnight TRLIBOR) at t period,
$\pi^e_{t+m/t}$ = annual inflation rate expected for m-period ahead at t period,
$\pi^t_{t+m/t}$ = annual inflation rate targeted for m-period ahead at t period,
$\pi^e_{t+n/t}$ = annual inflation rate expected for n-period ahead at t period,
$\pi^t_{t+n/t}$ = annual inflation rate targeted for n-period ahead at t period,
Y^{gap}_{t-k} = GDP gap at t-k period,
ε_t = error term.

The data are quarterly and cover the period 2006:2-2014:4 as the CBRT's expectations survey has presented data for 24-month ahead inflation expectations since the second quarter of 2006. Since data are quarterly, m=4 and n=8, the 12-month ahead inflation targets and 24-month ahead inflation targets for every period are obtained through the linear interpolation method. It is assumed that the CBRT may react to changes in the one-period lagged value of the output gap and thus k=1. The data are obtained from the CBRT, Turkish Statistical Institute, Banking Regulation and Supervision Agency in Turkey, and the Banks Association of Turkey.

Table 1: Descriptive statistics and correlation matrix for variables

	i	$(\Pi^e_{t+4}-\Pi^t_{t+4})$	$(\Pi^e_{t+8}-\Pi^t_{t+8})$	Y^{gap}
Descriptive statistics				
Mean	11.13	1.67	0.94	-0.025
Median	9.55	1.73	1.25	0.071
Maximum	18.75	3.56	2.36	1.48
Minimum	5.59	-0.59	-2.17	-2.93
Std. deviation	4.77	1.02	0.93	0.90
Observations	35	35	35	35
Correlation matrix				
i				
$(\Pi^e_{t+4}-\Pi^t_{t+4})$	0.62			
$(\Pi^e_{t+8}-\Pi^t_{t+8})$	-0.31	0.15		
Y^{gap}	-0.01	0.57	0.38	

Descriptive statistics and correlation matrix are presented in Table 1. As seen, all descriptive statistics of interest rate are greater than those of other variables. Additionally, interest rate is positively correlated with the difference between 12 month-ahead expected inflation rate and inflation target while it is negatively correlated with the other independent variables. Descriptive statistics are intended, of course, to provide one with some initial and/or preliminary inspection. However, beyond table observations, one needs to employ more reliable statistical methodologies to obtain unbiased and efficient output such as unit root and cointegration analyses.

4. Methodology and findings

4.1. Unit root tests

Unit root tests developed by Dickey and Fuller (1981, hereafter ADF) and Phillips and Perron (1988, hereafter PP) are commonly utilized in econometrics literature. The main shortcoming of these tests is that they do not take into account possible structural breaks in series. However, it should be considered that series may have structural breaks before a long-term relationship among variables is investigated. Hence it is recommended to employ unit root tests which regard structural breaks. While Perron (1989) test relies on the assumption that the time of the structural break is known, the unit root test produced by Zivot and Andrew (1992, hereafter ZA) test allows the structural break to be determined endogenously. The equations of ZA test are as follows:

Model A: (5)

$$y_t = \hat{\mu}^A + \hat{\theta}^A DU_t(\hat{\lambda}) + \hat{\beta}^A t + \hat{\alpha}^A y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^A \Delta y_{t-j} + \hat{e}_t \quad (5)$$

Model B: (6)

$$y_t = \hat{\mu}^B + \hat{\gamma}^B DT_t^*(\hat{\lambda}) + \hat{\beta}^B t + \hat{\alpha}^B y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^B \Delta y_{t-j} + \hat{e}_t \quad (6)$$

Model C: (7)

$$y_t = \hat{\mu}^C + \hat{\theta}^C DU_t(\hat{\lambda}) + \hat{\beta}^C t + \hat{\gamma}^C DT_t^*(\hat{\lambda}) + \hat{\alpha}^C y_{t-1} + \sum_{j=1}^{k} \hat{c}_j^C \Delta y_{t-j} + \hat{e}_t \quad (7)$$

Here, t = 1, 2, 3, ..., T shows the estimation period, TB shows the time of break, and $\hat{\lambda}$ = TB/T shows the break point. Model A shows the break in intercept, Model B shows the break in trend, and Model C shows the break in intercept and trend.

The dummy variables in the equations, $DU_t(\hat{\lambda})$ and $DU^*_t(\lambda)$, indicate the break in intercept and trend, respectively. The values of dummy variables are as below:

$$DU_t(\hat{\lambda}) = \begin{cases} 1 \text{ if } t>T\lambda \\ 0 \text{ if } t\leq T\lambda \end{cases}$$

$$DT^*_t(\hat{\lambda}) = \begin{cases} t-T\lambda \text{ if } t>T\lambda \\ 0 \text{ if } t\leq T\lambda \end{cases}$$

While applying the test, every period in the observation period is a possible break period and t-statistics regarding α parameter are obtained. After this process is applied to the all observation period, the period when t-statistic regarding α is minimum is a possible break period. The t-statistic obtained from the test is compared with the critical values that are constituted by Zivot and Andrews (1992). If |t-statistic|<|critical values| , the series has a unit root and is not stationary, and vice versa.

Table 2: ADF vs PP unit root tests

Variable[a]	ADF test statistic		PP test statistic	
	Intercept	Intercept and trend	Intercept	Intercept and trend
i	-1.40	-1.35	-1.39	-1.37
$(\Pi^e_{t+4}-\Pi^t_{t+4})$	-2.96[b]	-2.67	-2.14	-2.11
$(\Pi^e_{t+8}-\Pi^t_{t+8})$	-1.71	-3.90[c]	-2.03	-1.98
Y^{gap}	-2.53	-2.64	-1.69	-1.69
Δi	-5.95[b]	-6.06[b]	-5.94[b]	-6.20[b]
$\Delta(\Pi^e_{t+4}-\Pi^t_{t+4})$	-5.51[b]	-5.64[b]	-5.51[b]	-6.69[b]
$\Delta(\Pi^e_{t+8}-\Pi^t_{t+8})$	-4.13[b]	-4.19[b]	-4.29[b]	-4.38[b]
ΔY^{gap}	-4.34[b]	-4.29[b]	-4.34[b]	-4.24[b]
5% Critical value	-2.95	-3.54	-2.95	-3.55

Notes:
[a] Δ is the first difference operator.
[b] Illustrates statistical significance.

Table 3: ZA unit root test

Variablea	Model A[b]	Model B[b]	Model C[b]
	Test statistic	Test statistic	Test statistic
i	-4,37 (2009:1)	-3,65 (2010:1)	-4,53 (2009:1)
$(\Pi^e_{t+4}-\Pi^t_{t+4})$	-6,59[c] (2009:1)	-4,29 (2009:2)	-6,58[c] (2009:1)
$(\Pi^e_{t+8}-\Pi^t_{t+8})$	-3,24 (2007:4)	-4,19 (2010:3)	-7,22[c] (2008:2)
Y^{gap}	-2,34 (2009:3)	-2,53 (2011:2)	-3,60 (2009:3)
Δi	-6,52[c]	-6,35[c]	-6,58[c]
$\Delta(\Pi^e_{t+4}-\Pi^t_{t+4})$	-5,71[c]	-5,50[c]	-5,90[c]
$\Delta(\Pi^e_{t+8}-\Pi^t_{t+8})$	-9,13[c]	-5,71[c]	-9,39[c]
ΔY^{gap}	-6,86[c]	-4,69[c]	-6,70[c]
5% Critical value	-4.80	-4.42	-5.08

Notes:
[a] Δ is the first difference operator.
[b] Values in parentheses indicate breaking periods.
[c] Illustrates statistical significance.

Table 2 and Table 3 depict the results of unit root tests. Accordingly, the test statistics for the first differences reject the null hypotheses and indicate that series are stationary in the first-difference form. Hence it can be stated that the series are integrated of order one [I(1)].

4.2. Maki (2012) cointegration test

After determining the order of integration of variables, the next step is to examine whether there is a cointegration relationship among variables.

Maki (2012) propounds a cointegration test which regards structural breaks up to five different points in time. According to this cointegration test, every period in the sample is a possible breaking point and the corresponding statistics are computed for each period. Then, the lowest t-statistics determine the break points of time series period. Maki (2012) considers the following regression models to test for possible cointegration relation for multiple breaks as given in Equations (8) to (11):

Model 0: (8)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + u_t \quad (8)$$

Model 1: (9)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t} + u_t \quad (9)$$

Model 2: (10)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t} + u_t \quad (10)$$

Model 3: (11)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t} + u_t \quad (11)$$

where t =1,2,…,T. y_t and $x_t = (x_{1t},...,x_{mt})'$ and denote observable I(1) variables, and u_t is the equilibrium error, y_t is a scalar , and $x_t = (x_{1t},...,x_{mt})'$ is an (mx1) vector. Maki (2012) assumes that an (nx1) vector z_t is generated by $z_t = (z_t, x_t) = z_{t-1} + \varepsilon_t$, where ε_t are i.i.d. with mean zero, positive definite variance-covariance matrix Σ, and $E|\varepsilon_t|^s < \infty$ for some s>4. μ, μ_i, γ, γ_i, $\beta'=(\beta_1,..., \beta_m)$, and $\beta_i'=(\beta_{i1},..., \beta_{im})$ are true parameters. $D_{i,t}$ represents dummy variables taking a value of 1 if $t > T_{Bi}$ (i=1,…,k) and of 0 otherwise, where k is the maximum number of breaks and T_{Bi} denotes the time period of break. Equation (8) has the model with level shifts. Equation (9) allows for structural breaks of level and regressors. Equation (10) extends Equation (9) with a trend. The Equation (11) includes structural breaks of levels, trends, and regressors employed.

Table 4: Maki (2012) cointegration tests[a]

Model	Test statistic	Critical values[b]			Break dates
		1%	5%	10%	
0	-5.94[c]	-6.22	-5.70	-5.42	2006:4, 2009:1, 2012:3
1	-5.70[d]	-6.47	-5.95	-5.68	2009:2, 2011:2, 2014:2
2	-6.70	-7.76	-7.15	-6.86	2008:3, 2012:2, 2013:4
3	-6.98	-8.33	-7.74	-7.44	2009:3, 2010:4, 2012:4

Notes:
[a] The number of breaks is selected 3 due to the size of the sample.
[b] Critical values are obtained from Table 1 in Maki (2012).
[c] Illustrates 5% statistical significance.
[d] Illustrates 10% statistical significance.

The results for Maki (2012) cointegration test are depicted in Table 4. According to the results of the cointegration test, it can be claimed that there is a cointegration relationship among variables and that interest rates converge to its long-run equilibrium by correcting any possible deviations from this equilibrium in the short run.

Breaking periods indicated by ZA and Maki (2012) test show considerable events in the Turkish economy. Accordingly, some break periods show the periods when the Turkish economy is negatively affected by the 2008 global financial crisis while some correspond to periods when the Turkish economy grew fast with the help of intensive capital inflows. Additionally, some break periods indicate the periods in which the growth rates of the Turkish economy decelerated again.

4.3. Estimation of long-term coefficients

When the cointegration relationship is obtained among variables, the following process is to estimate long-term coefficients through the dynamic ordinary least squares (DOLS) approach produced by Stock and Watson (1993). Stock and Watson (1993) estimate a long-run dynamic equation that includes explanatory variables along with the leads and lags of differences of explanatory variables. This method corrects the possible endogeneity and serial correlation problems in the OLS estimation (Esteve and Requene, 2006). The DOLS model can be written as indicated in Equation (12).

$$y_t = \alpha_0 + \alpha_1 t + \alpha_2 x_t + \sum_{i=-q}^{q} \delta_i \Delta x_{t-i} + \varepsilon_t \tag{12}$$

where y, t, x, q, Δ, and e represent dependent variable, time trend, independent variable, optimum leads and lags, difference operator, and error term, respectively.

Table 5: Estimation of long-term coefficients[a]

Variable	Coefficient	Standard error	Prob-value
$(\Pi^e_{t+4} - \Pi^t_{t+4})$	6,83[b]	0,59	0,00
$(\Pi^e_{t+8} - \Pi^t_{t+8})$	-1,43	0,99	0,19
Y^{gap}	-3,65	2,39	0,16
d1	29,82	17,75	0,13
d2	11,77	10,52	0,30
d3	-9,01	7,15	0,24
$\bar{R}^2$ = 0,80. D-W ist. = 1,77.			

Notes:
[a] Break dates are selected based on model 1 in Maki (2012).
[b] Illustrates 1% statistical significance.

Dummy variables of breaking periods obtained from Maki (2012) cointegration test are included in the model to obtain long-term coefficients. The long-term coefficients estimated through the DOLS approach are denoted in Table 5. Estimation results give important information about the interest rate adjustments of the CBRT. Accordingly, the CBRT increases (decreases) overnight interest rates in response to an increase (decrease) in the difference between 12-month ahead expected inflation rate and inflation target. Thus it may be argued that the CBRT may have estimated that the effect of interest rate adjustments on inflation shows up in 12 months. In other words, it may be considered that the CBRT may have estimated that the monetary transmission lag for inflation in Turkey is one year. Another important finding from the estimation is that the CBRT does not react to changes in the one-period lagged value of the output gap. This may indicate that the CBRT reacts to changes in the expected output gap considering the lagged effect of monetary policy on output. However, for more reliable assessments, reaction function models that include the expected output gap should be estimated for the CBRT.

5. Conclusion

This paper investigates whether the CBRT reacts to changes in the difference between 12-month ahead expected inflation rate and inflation target or to changes in the difference between 24-month ahead expected inflation rate and inflation target by estimating the reaction function for the CBRT. After running ADF and ZA unit root tests, the paper employs Maki (2012) cointegration test. Then, the paper employs the DOLS estimator to obtain long-term coefficients. According to the findings obtained from the DOLS estimator, the CBRT reacts to changes in the difference between 12-month ahead expected inflation rate and inflation target. Thus it may be argued that the CBRT may have estimated the monetary transmission lag for inflation in Turkey is one year.

The CBRT has adopted an inflation targeting strategy since 2006. During the period 2006-2014, the CBRT achieved the inflation targets only in 2009 and 2010. As Svensson (1997) remarks, inflation is also affected by other factors besides monetary policy so central banks have imperfect control over inflation. Nevertheless, the paper findings beg one meaningful question: “Could the actual lag in monetary transmission mechanism be longer than the estimation of the CBRT?” This is a worthwhile question. Papers that will estimate the lags in monetary transmission mechanism are needed to find a convincing answer to this question. Findings presented herein could help the CBRT achieve inflation targets.

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