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The Monetary Policy Reaction Function in Turkey: Evidence from Fourier-Based Time Series Methods

Türkiye'de Para Politikası Tepki Fonksiyonu: Fourier Temelli Zaman Serisi Yöntemlerinden Bulgular

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ABSTRACT
The Central Bank of the Republic of Turkey (CBRT), which adopted an inflation targeting strategy in 2006, has thus far typically missed the inflation target. Therefore, this paper focuses on the monetary policy reaction function of the CBRT to detect the economic indicators that the CBRT considers while it is adjusting short-term interest rates. Put differently, the goal of this paper is to estimate a forward-looking monetary policy reaction function for the CBRT. To that end, the paper uses monthly data over the period 2006:1-2019:5. Differing from the previous papers in the empirical literature, this paper considers recent developments in time series analysis and employs time series methods based on the Fourier approximation to capture structural breaks. These methods are capable of presenting efficient and unbiased results in the presence of both sharp and gradual breaks. The findings indicate that the CBRT considers only inflation while it is steering short-term interest rates.

Keywords: Monetary policy reaction function, the Central Bank of The Republic of Turkey, Time series methods based on the Fourier approximation.
JEL Classification: C22, E43, E58

ÖZ
2006 yılında enflasyon hedeflemesi stratejisini benimseyen Türkiye Cumhuriyet Merkez Bankası (TCMB) bu zamana kadar genellikle enflasyon hedefini kaçırmıştır. Bu nedenle, bu çalışma TCMB'nin kısa vadeli faiz oranlarını ayarlarken hangi ekonomik göstergeleri dikkate aldığını tespit etmek için TCMB'nin para politikası tepki fonksiyonuna odaklanmaktadır. Diğer bir ifadeyle, bu çalışmanın amacı TCMB için ileri bakışlı bir para politikası tepki fonksiyonu tahmin etmektir. Bu amaç doğrultusunda, çalışmada 2006:1-2019:5 dönemine ait aylık veriler kullanılmaktadır. Literatürde yer alan önceki çalışmalardan farklı olarak, bu çalışma zaman serisi analizindeki güncel gelişmeleri dikkate alarak yapısal kırılmaları

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yakalamak için Fourier yaklaşımına dayalı zaman serisi yöntemleri kullanmaktadır. Bu yöntemler, hem keskin hem de aşamalı kırılmaların varlığında etkin ve sapmasız sonuçlar sunabilmektedir. Çalışmadan elde edilen bulgular, TCMB'nin kısa vadeli faiz oranlarını ayarlarken yalnızca enflasyon ile ilgilendiğine işaret etmektedir.

Anahtar kelimeler: Para politikası tepki fonksiyonu, Türkiye Cumhuriyet Merkez Bankası, Fourier yaklaşımına dayalı zaman serisi yöntemleri.
JEL Sınıflandırması: C22, E43, E58

1. Introduction

As Mishkin and Posen (1997) and Mishkin (1997) remarked, technological improvements led to the emergence of new financial instruments and increased the volatility of the velocity of money in 1980s, which in turn made it very difficult to control monetary aggregates for central banks and weakened the relationship between monetary aggregates and inflation. Therefore, today, many central banks in the world do not conduct monetary policy by trying to achieve a target for a monetary aggregate. Instead, they use the short-term (overnight) interest rate as the main monetary policy tool. Accordingly, they implement monetary policy principally by steering short-term interest rates since they have a great impact on money markets (Bondt, 2005). Then, monetary policy has a two-stage characteristic: while the changes in policy rates of central banks are conveyed to market interest rates at the first stage, changes in market interest rates influence retail bank interest rates for longer maturities, namely lending and borrowing rates, at the second stage (Bondt, 2005; Égert et al., 2007). Next, bank decisions for lending and borrowing rates influence medium- and long-term consumption and investment expenditures and thus economic activities and inflation (Bondt, 2005; Robertson, 2016).

In his pioneering study, Taylor (1993) tried to exhibit how the Federal Reserve adjusted the federal funds rate with regard to changes in inflation and output gap (the percentage difference between actual output and potential output). He revealed that there was a strong co-movement between the federal funds rate and the ratio he produced through a deterministic model. In the monetary economics literature, this model is referred to as "the Taylor rule". As Taylor (1993) did not consider the lagged effect of monetary policy on inflation, Clarida et al. (1998) suggested a forward-looking monetary policy reaction function (MPRF) considering monetary policy has a lagged influence on inflation. This MPRF includes the expected inflation rate instead of the current inflation rate. Afterwards, Clarida et al. (2000) propounded a reaction function by taking into account that monetary policy has a lagged influence on both inflation and output. Therefore, the MPRF produced by Clarida et al. (2000) involves expected inflation rate and expected output gap.

Inflation targeting (IT) is a monetary policy strategy that was first adopted in New Zealand in 1990. Under the IT strategy, (i) the central bank declares an inflation target, (ii) the main goal of the central bank is to achieve this target, and (iii) the central bank conducts monetary policy so that the inflation expectation is equal to the inflation target as there exists a high and positive correlation between inflation expectation and actual inflation (Svensson, 1997). The Central Bank of the Republic of Turkey (CBRT), which endorsed IT strategy in 2006, has missed its inflation targets up to the present except for in 2009 and 2010. Therefore, it is of crucial importance to focus on the monetary policy of the CBRT in terms of the MPRF. From the empirical literature, it can be observed that many studies have estimated the MPRF of the CBRT so far. One can notice that none of these papers considered recent developments in time series analysis in terms of structural breaks. Put differently, they did not consider structural breaks while estimating the MPRF of the CBRT. However, time series analysis has paid attention to structural breaks over the last three decades. While the early studies considered only sharp breaks, studies in recent years suggested unit root and cointegration tests which are capable of presenting efficient output irrespective of the form of the breaks, namely sharp or gradual.

Differing from the previous studies in the empirical literature, this paper takes structural breaks into account to estimate a forward-looking MPRF for the CBRT. While doing that, the paper considers recent developments in unit root and cointegration analyses and pays attention to gradual breaks. Hence, a key strength of the paper is to employ time series methods based on the Fourier approximation to capture structural breaks. To estimate the MPRF of the CBRT, the paper utilizes monthly data spanning the period 2006:1-2019:5.

The remainder of the paper is structured as follows: the Taylor Rule and forward-looking MPRFs are exhibited in Section 2. Section 3 presents the empirical literature on the MPRF of the CBRT. Section 4 is devoted to introducing the model and the data set. Section 5 presents methodology. Findings are reported in Section 6. Section 7 concludes the paper.

2. The Taylor Rule and Forward-Looking MPRFs

Taylor (1993) did not propose the Taylor rule as a consequence of academic debates or a comprehensive theoretical model (Bofinger et al., 2001). The Taylor rule is specified as the following:

$$r = p + 0.5y + 0.5(p - 2) + 2 \quad (1)$$

where r, p, and y respectively stand for the federal funds rate, the inflation rate over the previous four quarters, and output gap. Taylor (1993) did not estimate this model through statistical and/or econometric methods and posited that the Federal Reserve gave these weights (Judd and Rudebusch, 1998). Considering that monetary policy can influence future inflation rates rather than the current inflation rate, Clarida et al. (1998) propounded a forward-looking MPRF which can be demonstrated as follows:

$$i_t = \delta_0 + \delta_1 i_{t-1} + \delta_2 \pi^e_{t+n/t} + \delta_3 y_t + \varepsilon_t \quad (2)$$

where i_t is the overnight interest rate in the t period, i_{t-1} denotes the overnight interest rate in the t-1 period, $\pi^e_{t+n/t}$ stands for the annual inflation expectation for the n-period ahead in t period, y_t indicates the output gap in the t period, and ε_t is the error term. Clarida et al. (1998) remark that in the short-term prices are rigid and hence monetary is able to influence output with regard to their approach. They also add the one-period lagged overnight interest rate to the MPRF as central banks might smooth interest rates. Interest rate smoothing is the gradual adjustment of the overnight interest rate to the target rate. Lastly, Clarida et al. (2000) suggest a new MPRF including expected output gap rather than current output gap. This reaction function can be stated as the following:

$$i_t = \delta_0 + \delta_1 i_{t-1} + \delta_2 \pi^e_{t+n/t} + \delta_3 y^e_{t+m/t} + \varepsilon_t \quad (3)$$

where $y^e_{t+m/t}$ is the expected output gap for the m-period ahead in the t period. As is seen from Equation (3), the MPRF suggested by Clarida et al. (2000) posits that monetary policy has a lagged influence on both inflation and output.

3. Brief Literature

As was denoted previously, many studies estimated the MPRF of the CBRT for different sample periods and by employing different estimation methodologies. For instance, Berument and Malatyali (2000), utilizing data for the period 1989-1997 and performing the generalised method of moments (GMM) approach, find that the CBRT considers past inflation rates while adjusting short-term interest rates. Berument and Taşçı (2004) give evidence that the CBRT responds to changes only in output gap by using data over the period 1990-2000 and the GMM estimator. Yazgan and Yilmazkuday (2007) estimate the MPRF of the CBRT using data for the period 2001-2004. The findings of the GMM approach document that the CBRT deals with expected inflation and output gap while it does not change short-term interest rates as a result of a change in exchange rates. Adanur-Aklan and Nargelecekenler (2008) use data spanning the period 2001-2006 and carry out the GMM estimator to estimate the MPRF of the CBRT. They yield that the CBRT responds to changes in both past and expected inflation rates. Hasanov and Omay (2008) utilize data for the period 1990-2000 and perform the GMM approach to estimate a nonlinear MPRF for the CBRT. They find that the CBRT deals with both expected inflation and output gap. Gozgor (2012), who uses data over the period 2003-2012 and the GMM approach, yields that the CBRT takes inflation rates, output gap, and exchange rates into account while adjusting short-term interest rates. Bulut (2016) utilizes data for the period 2006-2014 and explores the CBRT responds to changes only in expected inflation rates through the dynamic ordinary least squares (DOLS) estimator. Öge-Güney (2016) estimates the MPRF of the CBRT over the period 2002-2014 via the GMM estimator. She finds that the CBRT considers expected inflation along with growth and inflation uncertainties. Erdem et al. (2017), who use data spanning the period

2006-2016 and perform the Kalman filter, discover that the CBRT considers expected inflation rates, output gap, exchange rates, and domestic credits while it is adjusting short-term interest rates. Öge-Güney (2018) and Caporale et al. (2018), who respectively use data over the period 2002-2015 and for the period 2006-2015, estimate a nonlinear reaction function for the CBRT. Both papers give evidence that the CBRT considers both expected inflation and output gap while steering short-term interest rates. Finally, Bulut (2019), utilizing data 2006-2018 and performing an asymmetric cointegration test, finds that the CBRT takes both expected inflation rates and output gap into account while it is conducting monetary policy.

As is seen from the previous empirical literature, none of the papers focusing on the MPRF of the CBRT considered structural breaks. Therefore, the main distinguishing feature of the present paper is that it is the first paper that takes structural breaks into account while estimating the MPRF of the CBRT. Moreover, the estimation methodologies in the paper are able to present efficient output under both sharp and gradual structural breaks.

4. Model and Data

To detect the variables responded by the CBRT, this paper uses a forward-looking MPRF produced by Clarida et al. (1998). Three issues need to be emphasized at this stage. First, the MPRF does not include the previous interest rate as the paper does not examine whether the CBRT gradually adjusts interest rates. Second, following Yazgan and Yilmazkuday (2007), the MPRF involves the difference between the expected inflation rate and the target inflation rate as inflation targets of the CBRT are not fixed over the period under consideration. Third, the CBRT announces only year-end and next year-end annual growth expectations. Therefore, the paper employs a Clarida et al. (1998)-type reaction function rather than a Clarida et al. (2000)-type reaction function. The MPRF used in this paper is exhibited as the following:

$$i_t = \beta_0 + \beta_1(\pi^{e}_{t+m/t} - \pi^{tar}_{t+m/t}) + \beta_2 y^{gap}_t + \varepsilon_t \quad (4)$$

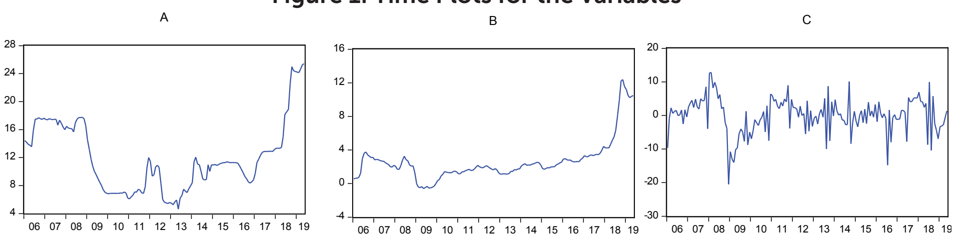
In Equation (4), i_t is overnight interest rates (TRLIBOR) in t period, $\pi^{e}_{t+m/t}$ stands for the annual expected inflation rate based on the consumer price index (CPI) for m-period ahead in t period, $\pi^{tar}_{t+m/t}$ denotes the annual target inflation rate based on CPI for m-period ahead in t period, y^{gap}_{t} is output/industrial production gap in the t period, and ε_t indicates the error term. The paper utilizes monthly data spanning the period 2006:1-2019:5. Following the previous papers in the empirical literature, m is equal to 12 (Yazgan and Yilmazkuday, 2007; Bulut, 2016; Öge-Guney, 2016). Put differently, the present paper assumes the CBRT can consider the difference between a 12-month ahead expected inflation rate and the inflation target. While interest rates data is sourced from the Banks Association of Turkey (2019), the data for inflation and industrial production index is extracted from the CBRT (2019). To obtain inflation expectations, the CBRT's survey of expectations is used. Additionally, industrial production index data is detrended using the filter of Hodrick and Prescott (1997) to acquire industrial production gap.

Table 1: Descriptive Statistics for the Variables

	i_t	$(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$	y^{gap}_{t}
Descriptive statistics			
Mean	11,997	2,608	0,041
Median	11,221	2,130	0,533
Maximum	25,403	12,380	12,779
Minimum	4,626	-0,598	-20,465
Std. deviation	4,901	2,413	5,318
Correlation matrix			
i_t			
$(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$	0,735		
y^{gap}_{t}	0,064	0,075	

Source: Author's calculations.

Figure 1: Time Plots for the Variables



Note: A, B, and C respectively stand for i_t, $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$, y^{gap}_{t}.

Table 1 reports descriptive statistics and correlation matrix for the variables. Accordingly, all descriptive statistics except for standard deviation of i_t are higher than those of $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ and y^{gap}_{t}. Besides, i_t is positively correlated with $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ and y^{gap}_{t} while $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ and y^{gap}_{t} are positively correlated with each other. Figure 1 demonstrates the time series dynamics of the variables in the empirical model. As is seen, i_t and $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ tend to increase in the last months of the sample period under consideration. Additionally, y^{gap}_{t} rapidly decreased at the end of 2008 as a result of the global financial crisis. The descriptive statistics and graphical observations provide researchers with some preliminary inspections about the variables. Yet, researchers must employ some statistical/econometric techniques beyond these analyses to obtain efficient and unbiased findings for the relationships between the variables. Hence, the following section presents the estimation methodology.

5. Estimation Methodology

This section presents the estimation methods employed in the paper.

5.1. The Enders and Lee (2012) Unit Root Test

Previous papers in unit root analysis that consider structural breaks, namely Zivot and Andrews (1992), Lee and Strazicich (2003), and Narayan and Popp (2010), paid attention to a certain number of breaks and also assumed that breaks in series occur promptly. Put differently, these tests considered a definite number of sharp breaks. Enders and Lee (2012, henceforth E&L) propound a unit root test which is capable of presenting efficient findings about the stationarity of variables irrespective of the number and the form, namely sharp or gradual, of breaks.

E&L begin with the following model defined as

$$y_t = \alpha(t) + \rho y_{t-1} + \gamma t + \varepsilon_t \qquad (5)$$

where ε and α(t) respectively stand for the stationary error term and the deterministic function of t. E&L consider the following Fourier expansion when the form of α(t) is unknown:

$$\alpha(t) = \alpha_0 + \sum_{k=1}^{n} \alpha_k \sin(2\pi kt/T) + \sum_{k=1}^{n} \beta_k \cos(2\pi kt/T), \quad n \leq T/2 \qquad (6)$$

In Equation (6), n, k, and T are the number of frequencies, the particular frequency, and the number of observations, respectively.

E&L suppose a single frequency k and consider the following regression in their study:

$$\Delta y_t = \rho y_{t-1} + c_1 + c_2 t + c_3 \sin(2\pi kt/T) + c_4 \cos(2\pi kt/T) + e_t \qquad (7)$$

In Equation (7), E&L compare the statistic with the critical values depending on the frequency and the sample size to test for the null hypothesis of a unit root defined as ρ = 0. If the calculated statistic is greater than the critical values, the null hypothesis of a unit root is rejected, implying the series is determined to be stationary.

5.2. The Tsong et al. (2016) Cointegration Test

Just like for unit root analysis, previous papers in cointegration analysis that regard structural breaks, such as Gregory and Hansen (1996), Hatemi-J (2008), and Maki (2012), focused on a definite number of sharp breaks. Hence, the estimated break date and the form of the break are crucial in terms of the performances of these tests. Using the Fourier approach, Tsong et al. (2016) suggest a cointegration test which is able to yield efficient findings irrespective of the number and the form of breaks, i.e. sharp or gradual. This test propounds a pretesting to investigate whether or not the model should involve the Fourier component as well.

Tsong et al. (2016) begin with the following model:

$$y_t = d_t + x_t'\beta + \eta_t, \;\; d_t = \delta_0 + f_t, \;\; \eta_t = \gamma_t + \upsilon_{1t}, \quad \gamma_t = \gamma_{t-1} + u_t, \;\; x_t = x_{t-1} + \upsilon_{2t} \qquad (8)$$

where u_t is the error term and f_t is the Fourier function which is defined as

$$f_t = \alpha_k \sin\left(\frac{2k\pi t}{T}\right) + \beta_k \cos\left(\frac{2k\pi t}{T}\right) \tag{9}$$

where k, t, and T stand for the Fourier frequency, time trend, and the number of observations, respectively. The null hypothesis of cointegration can be described as follows:

$$H_0: \sigma_u^2 = 0 \text{ versus } H_1: \sigma_u^2 > 0 \tag{10}$$

To test for the null hypothesis of cointegration, the model is exhibited as

$$y_t = \sum_{i=0}^{m} \delta_i t^i + \alpha_k \sin\left(\frac{2k\pi t}{T}\right) + \beta_k \cos\left(\frac{2k\pi t}{T}\right) + x_t'\beta + \upsilon_{1t} \tag{11}$$

For the test, the cointegration test statistic is described as the following

$$CI_f^m = T^{-2}\hat{\omega}_1^{-2} \sum_{t=1}^{T} S_t^2 \tag{12}$$

where $S_t = \sum_{t=1}^{T} \hat{\upsilon}_{1t}$ shows the partial sum of the ordinary least squares (OLS) residuals in Equation (11) and $\hat{\omega}_1^2$ is the estimator of the long-run variance of υ_{1t}.

Tsong et al. (2016) also control for the null hypothesis of the absence of the Fourier component, namely $H_0: \alpha_k = \beta_k = 0$, through the following F test:

$$F^m(k^*) = \max_{k\in\{1,2,3\}} F^m(k) \tag{13}$$

where

$$F^m(k) = \frac{(SSE_0^m - SSE_1^m(k))/2}{\frac{SSE_1^m(k)}{(T-q)}} \tag{14}$$

where SSE_0^m and $SSE_1^m(k)$ are respectively the sum of squares residuals acquired from the estimation of Equation (11) under the null and the alternative hypotheses.

Additionally, q is the number of the parameters under the alternative hypothesis. Tsong et al. (2016) carry out the DOLS estimator suggested by Saikkonen (1991) and Stock and Watson (1993) to estimation Equation (11).

6. Results and Discussion

The paper first executes the E&L unit root test. The test statistics along with the optimal frequencies for all variables are reported in Table 2. Accordingly, the null hypothesis of a unit root can be rejected at first differences for all variables in the empirical model. In other words, the findings obtained from the E&L unit root indicate that all variables are integrated of order one and that the Tsong et al. (2016) cointegration test can be performed to examine the cointegration relationship in the model.

Table 2: E&L Unit Root Test[a]

Variable[b]	Optimal frequency	Test statistic
i_t	1	-2,393
$(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$	1	-3,282
y^{gap}_{t}	4	-3,160
Δi_t	2	-8,714[c]
$\Delta(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$	2	-6,920[c]
Δy^{gap}_{t}	4	-5,874[c]

Notes: [a]Critical values are obtained from E&L (2012). [b]Δ is the first difference operator. [c]Illustrates 1% statistical significance.

Table 3 depicts the results of the Tsong et al. (2016) cointegration test together with the long-run parameters of the independent variables in the model. Accordingly, panel A of the table indicates that the null hypothesis that there is no need to add the Fourier component to the empirical model is rejected at 1% level, implying the Tsong et al. (2016) cointegration test should be exploited to examine the cointegration relationship in the model. Panel A also shows that the null hypothesis of cointegration cannot rejected with the optimal frequency 1, meaning there is a cointegration relationship in the model and the long-run coefficients can be estimated through the DOLS estimator. Panel B of the table presents the estimations of long-run coefficients. Accordingly, $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ and y^{gap}_{t} respectively have the estimations of 1,557 and 0,034. Besides, the coefficient of $(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$ is statistically significant at 1% level, whereas that of y^{gap}_{t} is statistically insignificant.

Table 3: Results of the Cointegration Test[a]

Panel A: Results of the cointegration test			
Frequency	**Min SSR**	**Test statistic**	**F-statistic**
1	431,616	0,154	189,147[b]
Panel B: DOLS results			
Variable	**Coefficient**	**Std, error**	**t-statistic**
$(\pi^{e}_{t+12/t} - \pi^{tar}_{t+12/t})$	1,557[b]	0,161	9,794
y^{gap}_{t}	0,034	0,152	0,227

Notes: [a]For critical values of the cointegration tests, see Tsong et al. (2016). [b]Illustrates 1% statistical significance.

Hence, this paper provides evidence that the CBRT considers the difference between the expected inflation rate and the inflation target while it is adjusting short-term interest rates. Besides, it can be observed from the previous empirical literature that the findings of this paper concur with those of Adanur-Aklan and Nargelecekenler (2008) and Bulut (2016), who show that the CBRT considers only inflation while conducting monetary policy.

7. Conclusion

This paper estimated a forward-looking MPRF for the CBRT using monthly data over the period 2006:1-2019:5 through recently developed time series methods based on the Fourier approximation to capture structural breaks. The paper first performed the E&L unit root test and detected all the variables were integrated of order one. Then, it employed the Tsong et al. (2016) cointegration test and determined that there existed a cointegration relationship in the empirical model. Finally, it executed the DOLS estimator to obtain the long-run coefficients. The findings of the DOLS estimator implied that the CBRT considered only the difference between the expected inflation rate and the inflation target, indicating a change in output gap did not result in any changes in the interest rate adjustments of the CBRT.

Based on the empirical findings, the paper argues that supply-side factors may play a role in the missed inflation targets in Turkey. Some recent papers by Tunc and Kilinc (2018) and Ertug et al. (2018) give evidence of a strong exchange rate pass-through to domestic prices in Turkey. Furthermore, the paper contends that the reaction of interest rates to a change in the difference between the expected inflation rate and the inflation target might be insufficient. Therefore, the paper advocates that a more aggressive monetary policy might help the CBRT to achieve inflation targets. Finally, there is no doubt that the CBRT should not ignore the influence of this contractionary monetary policy on output while it is steering short-term interest rates. Last but not least, this paper remarks that future papers should consider estimating a Clarida et al. (2000)-type reaction function if the CBRT begins to announce expected output/output gap data for different time horizons, i.e., 6-month ahead or 12-month ahead expected output/output gap data.

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