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**Article**

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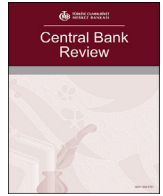
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# Responsiveness of monetary policy to financial stress in Turkey<sup>☆</sup>



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## ABSTRACT

The objective of this paper is to investigate whether the Central Bank of Turkey (CBRT) was responsive to financial stress or not during the period 2005m1–2015m10. The study is unique in the sense that CBRT's monetary policy reaction function is augmented with a distinctive financial stress index, i.e. the composite index of systemic stress (CISS). The index pays special attention to the systemic risk component of financial markets by taking into account the cross-correlations between financial market segments. The responsiveness of the CBRT to financial stress is measured by a generic policy interest rate, comprising of the overnight rate, BIST interbank rate and weighted average funding rate. CBRT has publicly announced the change in its policy framework as a response to heightened financial stability concerns after the third quarter of 2010. This study aims to look whether the CBRT's response to financial systemic stress has really changed or not after 2010 by carrying out a subsample regression analysis. The results are further crosschecked with rolling window and interaction dummy regression analysis. The empirical results collected from these econometric exercises indicate that the CBRT's monetary policy was leaning more against financial stress after mid-2010 compared to the previous period.

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## 1. Introduction and literature review

The unprecedented economic recession in the aftermath of the global financial crisis revealed how important it is that central banks step in at an early stage to control for financial risks and mitigate the effects of financial crisis on the economy. Since then, serious academic work has been initiated in terms of monitoring and predicting financial instability, also how early warning mechanisms against financial imbalances should be in place for a timely intervention. It is now well understood that, when financial imbalances are left unattended, the accumulation, persistence and unfolding of financial imbalances might gradually lead to a collapse in real economic activity (Hakkio and Keaton, 2009; Brave and Butters, 2011a, 2011b; Cardarelli et al., 2011; Oet et al., 2011; Lo Duca and Peltonen, 2013).

In this context, the notion of modifying the monetary policy strategy of central banks in order to ensure that simultaneously maintaining price and financial stability has lately become a

popular discussion among central bankers and academics. Before the global financial crisis, central banks were more inclined to embrace the 'clean after burst' view of financial stability, implying that central banks should disregard financial issues largely and focus solely on price stability. The main argument of this view was that sustaining price stability would be enough to secure both sustainable economic growth and stable financial markets. Central banks need to intervene only if there is a financial crisis and help to clean the markets afterwards. The opposite standpoint of this view is formed by the 'lean against the wind' approach, suggesting that the central bank and monetary policy should be more proactive in containing financial risks and preventing financial crises (Borio, 2009, 2011; White, 2009; Smets, 2013).

As a reflection of these discussions after the global financial crisis, many researchers started to take a closer look into the relationship between monetary policy, real economic activity and financial stress. Bauducco et al. (2008) shows in a DSGE model that monetary policy is sensitive to credit risk. According to the study, when financial instability affects output and inflation with a lag and the central bank has privileged information about credit risk, monetary policy that responds instantly to increased credit risk can trade off more output and inflation instability today for a faster return to the trend than a policy that follows the simple Taylor (1993) rule with only the contemporaneous output gap and

<sup>☆</sup> Views and opinions presented in this study belong to the author and do not necessarily represent those of the Central Bank of the Republic of Turkey or its staff.

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inflation.

**Bulir and Cihak (2008)** address the question whether and how stabilization policies react to financial sector vulnerability. They formulate a testable model of why monetary authorities may decide to conduct loose monetary policy in the face of financial sector vulnerability. Using cross-country panel data estimation, they find support for the hypothesis of deliberately lower policy interest rates when the financial sector appears unstable. This finding is in line with the clean after burst view of central banking.

**Castro (2007)** analyses whether a forward-looking monetary policy reaction function can be augmented with a financial conditions index containing information from some asset prices and financial variables. This approach is very similar to the exercise carried out in our paper. The results indicate that the monetary behavior of the ECB and Bank of England is best described by a nonlinear rule, but the behavior of the FED can be well described by a linear **Taylor (1993)** rule. The evidence also suggests that only the ECB is reacting to financial conditions.

In a similar way, **Baxa et al. (2011)** examine whether and how selected central banks responded to episodes of financial stress over the last three decades. They employ a new monetary-policy rule estimation methodology which allows for time-varying response coefficients and corrects for endogeneity. Their findings are in support of **Castro (2007)** and suggest that central banks often change policy rates, mainly decreasing them in the face of high financial stress. However, the size of the policy response varies substantially over time as well as across countries, with the 2008–2009 financial crises being the period of the most severe and generalized response. With regard to the specific components of financial stress, most central banks seemed to respond to stock-market stress and bank stress, while exchange-rate stress is found to drive the reaction of central banks only in more open economies.

**Milas and Naraidoo (2011)** investigate how ECB sets interest rates in the context of both linear and nonlinear policy reaction functions. It contributes to the current debate on central banks having additional objectives over and above inflation and output. Three findings emerge: First, the ECB takes financial conditions into account when setting interest rates. Second, amongst **Taylor (1993)** rule models, linear and nonlinear models are empirically indistinguishable within sample and model specifications with real-time data provide the best description of in-sample BoE interest rate setting behavior. Third, the 2007–2009 financial crisis witnesses a shift from inflation targeting to output stabilization and a shift, from an asymmetric policy response to financial conditions at high inflation rates, to a more symmetric response irrespectively of the state of inflation.

**Martin and Milas (2013)** investigate the monetary policy reaction of the BoE for the period 1992–2010 and found that until 2007, the monetary policy can be explained by the original **Taylor (1993)** Rule. However, a fracture occurred in the subsequent period and the monetary policy regime of the BoE shifted to crisis regime. Since 2007, the monetary policy response to inflation weakens, while the reaction to the output gap has reduced significantly. To explain the structural break in the monetary policy regime, the examination period is created as the weighted average of “financial crisis regime” and “crisis-free regime” periods. These weights reflect the possibility of the occurrence of a financial crisis. In this sense, the crisis-free regime refers to the original **Taylor (1993)** Rule, while the financial crisis regime indicates a period of low response to output gap, insensitivity to inflation rate and severe financial stress. In this context, even if the actual inflation rate was above the target inflation rate after 2007, contrastingly, financial stress led to a sharp lowering of policy rates in the UK.

To my knowledge, this paper is the first to augment the CBRT policy reaction function with a distinctive financial stress index, i.e. the composite index of systemic stress (CISS), and investigate

CBRT's responsiveness to financial stress for Turkey. This exercise is important for two reasons: First, after mid-2010 the CBRT has announced a new policy framework in which it gears up its financial stability role. Therefore, it is reasonable to assume that, since then, it started to pay attention to systemic financial shocks. As financial stress evolves into a systemic crisis it becomes a bigger threat to macroeconomic stability, meaning that CBRT's primary concern, price stability, would be endangered fundamentally. Hence, financial stability has become a goal for monetary policy after 2010 in Turkey (**Kara and Başçı, 2011**).

Second, the CISS is financial stress index that measures the stress in financial markets in a more complex and comprehensive way other than standard financial stress indicators. In the CISS method, the co-movement of stress in the money, bond, equity, banking and forex submarkets are taken into account by considering the cross-correlations. Thus, compared to an unweighted standard financial stress index, in the CISS method financial stress becomes systemically high when stress level is high in all of the five submarkets and low in reverse situations. This gives the CISS a horizontal perspective in terms of a systemic stress index. The vertical property of the CISS comes from its relationship with real economic activity. The relationship is taken into account by weighting the submarkets according to the relationship between all submarket stress levels with the Turkish industrial production index. The submarket stress level that has a stronger relation with industrial production is considered to have larger weight in the final aggregation of the Turkish CISS (For more detailed information see Section 2 and **Çamlıca and Güneş (2016)**).

## 2. Methodology

In this section, the data used in the estimation model is described in detail. Thereafter, the results of the unit root tests are introduced to the reader. Finally, the specification of the model and the estimation method is outlined.

### 2.1. Data

Monthly data is used covering the period 2005m1–2015m11. All data are taken from the EVDS database and the expectations survey of CBRT. The data generation process for all the time series is carried out as the following:

- > Ex-post Inflation Rate and Inflation Expectations: Ex-post inflation rate is calculated with the following formula:  $INF_{\text{expost}} = 100 * (\log(CPI_t) - \log(CPI_{t-12}))$ . One year ahead inflation expectations obtained from the survey is incorporated into the model as appropriate average estimates based on market forecasts ( $INF_{\text{forecast}}$ ).
- > Output Gap: We follow **Belke and Polleit (2007)** and employ the Hodrick-Prescott filter to seasonally adjusted monthly industrial production index using the following formula:  $Y_{\text{gap}} = 100 * (\text{HP-filter}(\log(IP_t)))$ .<sup>1</sup>
- > Policy Rate: For the period 2005m1–2010m12, Turkish Lira overnight interest rate (ON) is used as a proxy for the CBRT policy interest rate. For the later period of 2011m1–2015m11, we follow **Mahir Binici, Hakan Kara, Pınar Özlü (2016)** and generated the policy rate proxy as a generic policy rate calculated by taking the 40% of average funding rate and 60% of BIST interbank rate. Real interest rate is assumed to be constant in

<sup>1</sup> Output gap is a discussion in the Taylor rule literature as a result of the difficulties arising from estimating the output gap in a correct way. For a detailed discussion see **Orphanides and Wieland (2012)**.

**Table 1**  
Descriptive statistics.

	Generic Interest rate	Output Gap	Inflation (Expost)	Inflation (Forecast)	CISS Turkey
Mean	11.13368	-0.000000001	7.955483	6.918308	0.120398
Median	9.615	0.686662	7.857089	6.855	0.098503
Maximum	19.10061	11.765	11.39054	9.23	0.533316
Minimum	4.988	-20.33532	3.908645	5.45	0.016973
Std. Dev.	4.450952	5.134382	1.563211	0.706198	0.087393
Observations	130	130	130	130	130

order to overcome the uncertainty surrounding policy rates [Table 1](#).

**2.2. Estimation method of the CISS**

The most important and unique variable in this study is the CISS, estimated with a technique borrowed from [Hollo et al. \(2012\)](#). The CISS is a composite indicator of financial risk in the money, credit, bond, equity and forex markets. The index pays special attention to the systemic risk component of financial markets by taking the cross-correlations between financial market segments into consideration when estimating the CISS.<sup>2</sup>

By applying the portfolio theory, the CISS obtains a systemic property with a *horizontal perspective*. This is due to the fact that the CISS puts relatively higher weights on situations in which stress prevails in a number of sub-markets at the same time as a result of taking the cross-correlations between five sub-indices into account when aggregating sub-indices.

Furthermore, the calibration of the weights assigned to each sub-index introduces a *vertical perspective* to the systemic nature of the CISS. The vertical perspective considers the relationship between the financial system and the real economy by measuring the impact that the former has on the latter.

The CISS is calculated according to the formula as follows:

$$CISS_t = (w_t \circ s_t) C_t (w_t \circ s_t)' \tag{1}$$

with  $w_t = (w_{i,t})$  a vector consisting of sub-index weights and  $s_t = (s_{i,t})$  a vector including sub-indices with  $i = 1,2,5$ ;  $w_t \circ s_t$  the Hadamard-product of both vectors; and  $C_t$  is a  $5 \times 5$  matrix including the time varying cross-correlation coefficients between sub-indices. At the end of this computation, a continuous and unit free indicator within the half-open interval (0; 1] has been obtained as composite indicator of financial systemic stress.

The time varying cross-correlations between sub-indices ( $\rho_{ij,t}$ ) that represent the horizontal dimension of the CISS are calculated recursively through the exponentially-weighted moving average (EWMA) of sub-index variances  $\delta_{ij,t}$  and variances  $\delta_{i,t}^2$  by the formulas as follows:

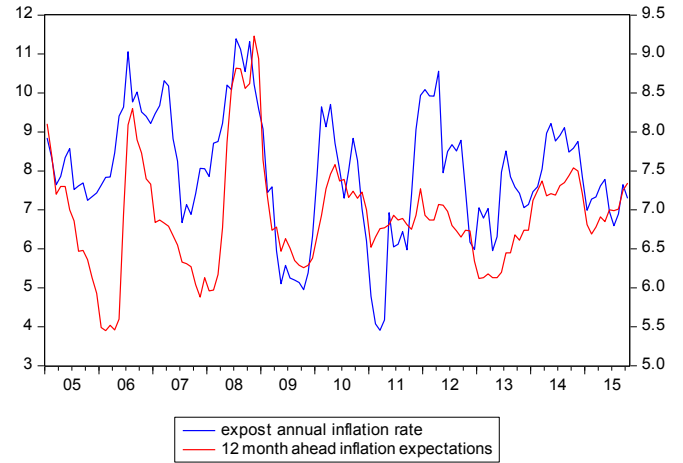
$$\delta_{ij,t} = \lambda \delta_{ij,t-1} + (1 - \lambda) \widetilde{s_{i,t}} \widetilde{s_{j,t}} \tag{2}$$

$$\delta_{i,t}^2 = \lambda \delta_{i,t-1}^2 + (1 - \lambda) \widetilde{s_{i,t}}^2 \tag{3}$$

$$\rho_{ij,t} = \delta_{ij,t} / (\delta_{i,t} \delta_{j,t}) \tag{4}$$

The lambda value in the EWMA estimation of the cross-correlations is 0.93 in line with [Hollo et al. \(2012\)](#).  $\widetilde{s_{i,t}}$  denoting demeaned submarkets obtained by subtracting their *theoretical*

<sup>2</sup> Portfolio theoretic weighting method is previously used in [Kilimci et al. \(2014, 2015\)](#) in which they estimated a forex market stress index and bond market liquidity index respectively. However, these studies differ from [Camlica and Gunes \(2016\)](#) data standardization and transformation.



**Graph 1.** Expost inflation rate and inflation forecast.

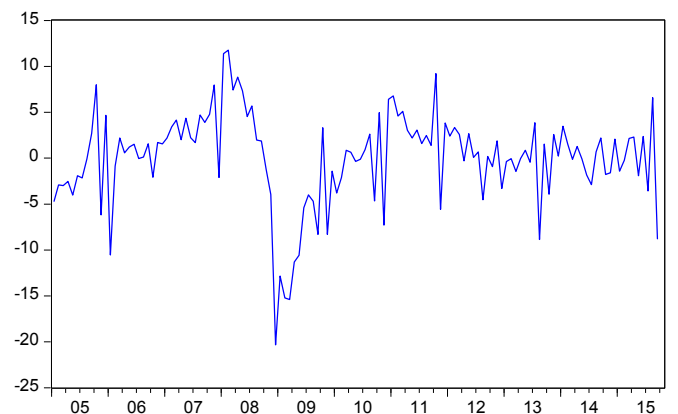
median of 0.5.

The submarket index weights indicated in [formula 3](#),  $w_t = (w_1, w_2, w_3, w_4, w_5)$ , were calibrated with a bivariate VAR regression between industrial production growth and the sub-market stress indices. The weights are determined by the share of every sub-index in the total 24-month accumulated impulse responses of all five sub-indices ([Graphs 1–3](#)).

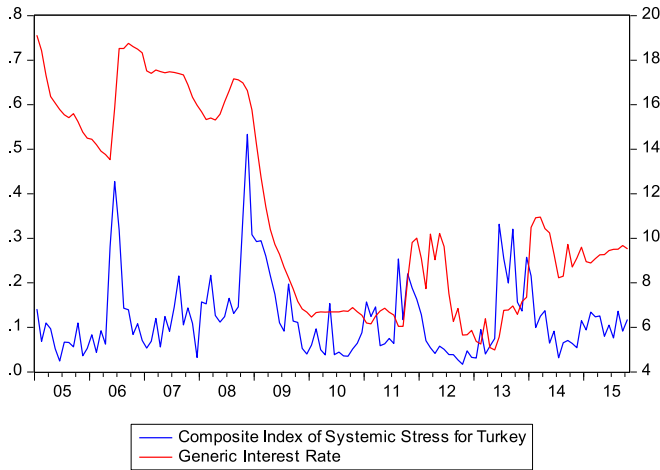
Finally, the sample is split into subsamples according to the timing of the shift in CBRT’s policy framework. We follow [Kara and Başçı \(2011\)](#) and take mid of 2010 as our reference point and split the sample in two periods defining the subsample periods as regime I and II.

**2.3. Unit root analysis**

[Table 2](#) presents the unit root test results. Other than the overnight interest rate all series manage to pass the classic stationary tests. It is worth to be suspicious about this conclusion as the classic unit root test does not take into account structural breaks, which



**Graph 2.** Output Gap (HP filtered Industrial Production).



Graph 3. Overnight interest rate and financial stress index.

might be an important characteristic of the ON data given the sample period.

Therefore, a breakpoint DF unit root test is employed to take account of the break. The result shows that there is indeed a break during the global crisis in 2008m11. The unit root in the ON series can be rejected at the 5% significance level. Therefore, we conclude that the unit root in the series is the result of a structural break in the ON series.

#### 2.4. Estimation model and method

In equation (1) the central bank is changing the policy rate,  $i_t$ , if inflation rate deviates from the target inflation rate ( $\pi_t - \pi^*$ ) and/or nominal output deviates from potential output ( $y_t - y_t^*$ ). The weights of inflation and economic activity in the reaction function are indicated by parameters  $\beta_\pi$  and  $\beta_y$ , respectively. Moreover, the rule is augmented with CISS, implying that the central bank is giving some weight to one period lagged financial systemic stress besides inflation and output gap in its monetary policy loss function, indicated by  $\beta_{CISS}$ . This is more realistic as it is hard for the central bank to capture the nature of financial stress in the very same month. This is important as a financial stress episode can start in a month after the monetary policy decision of a central bank takes place and hence the increase of financial stress will not be included in the current central bank response.

Here, we estimate a second model, equation (6) with the assumption that the central bank is conducting monetary policy with a forward-looking behavior.<sup>3</sup> This is a realistic assumption given that the CBRT is implementing IT. In other words, the central bank is taking policy decisions by looking at the one year ahead inflation forecast, contemporaneous output gap and financial stress.

$$i_t = \delta(i_{t-1}) + (1 - \delta) \left\{ c + \beta_{\pi,2} \left[ E(\pi_{t+12} - \pi^*) \right] + \beta_{y,2} (y_t - y_t^*) \right. \\ \left. + \beta_{CISS,2} (CISS_{t-1}) \right\} + \varepsilon_t \quad (6)$$

In equations (5) and (6)  $u_t$  and  $\varepsilon_t$  represents exogenous policy rate shocks, respectively.

The Generalized Method of Moments (GMM) is used for estimating the models. GMM is considered to take care of the potential endogeneity problems in the estimation of the policy reaction rule.<sup>4</sup> Under the assumption of an augmented policy rule, observed inflation, output gap and financial stress are, in fact, unobservable variables at the moment of the policy rate decisions. Hence, it is highly possible that explanatory variables and the error term are correlated at time  $t$ , leading to endogeneity or simultaneity problems (Verbeek, 2004; Clarida et al., 1998).

It is important that the GMM estimation of the policy reaction rule requires the identification of the orthogonality conditions. Retrieving the additional information needed from the moment conditions is essential to estimate unbiased and consistent parameter estimates with the GMM estimator. The GMM estimator is using the information provided by introducing instrumental variables that satisfy two conditions: First, instrumental variables and the error term must be uncorrelated. Second, instrumental variables and explanatory variables needs to be highly correlated. Thus, the lagged values of inflation and economic activity that are strongly correlated with the explanatory variables, but not with the error term at time  $t$ , can be described as the natural candidates for instrumental variables. Also, contemporaneous variables regarded as exogenous can be identified as instrumental variables (Verbeek, 2004; Hayashi, 2000; Zsohar, 2012).

Hence,  $Z_t$  can be identified as a set of observable variables by the central bank at time  $t$  that is uncorrelated with the error term. In this respect, given that  $E(u_t | Z_{t,1}) = 0$  and  $E(\varepsilon_t | Z_{t,2}) = 0$ , the orthogonality conditions to utilize for the estimation of equations (7)–(8) can be written in the following way:

$$E \left( i_t - \delta(i_{t-1}) - (1 - \delta_1) \{ c + \beta_{\pi,1} (\pi_t) - \beta_{y,1} (y_t - y_t^*) - \beta_{CISS,1} (CISS_{t-1}) \} | Z_{t,1} \right) = 0 \quad (7)$$

$$E \left( i_t - \delta(i_{t-1}) - (1 - \delta_2) \{ c + \beta_{\pi,2} (\pi_{t+12}) - \beta_{y,2} (y_t - y_t^*) - \beta_{CISS,2} (CISS_{t-1}) \} | Z_{t,2} \right) = 0 \quad (8)$$

Also, the lagged value of the policy interest rate, indicated by parameter  $\delta$ , is included in the equation as the interest rate smoothing term. The real interest rate is assumed to be fixed, which can be seen as a restrictive assumption of the model. Hence, the constant term in the estimation model,  $c$ , represents the real interest rate.

$$i_t = \delta(i_{t-1}) + (1 - \delta) \left[ c + \beta_{\pi,1} (\pi_t - \pi^*) + \beta_{y,1} (y_t - y_t^*) \right. \\ \left. + \beta_{CISS,1} (CISS_{t-1}) \right] + u_t \quad (5)$$

<sup>3</sup> Although, there is no consensus on how long the medium term is in monetary policy, the medium term is considered as one year in this study.

<sup>4</sup> GMM stands out among other methods as it allows retrieving unbiased and consistent parameter estimates in single equation models with endogeneity problems. GMM is also preferred because it can handle heteroscedasticity and autocorrelation problems. Also, the GMM estimator does not require strong distributional assumptions, which is obviously a strong advantage over the Ordinary Least Squares (OLS) method.

**Table 2**  
Unit root analysis.

Variables	ADF Test		KPSS Test		DF Breakpoint Test	
	Constant	Constant Trend	Constant	Constant Trend	Constant	Constant Trend
Interest rate	-1.771164	-1.674284	0.9642	0.2057	-4.742**	-4.907**
Inflation rate	-2.938975**	-3.510721**	0.1969***	0.0602***		
Inflation forecast	-4.460505***	-4.457273***	0.0456***	0.0458***		
Output gap	-3.2522**	-3.2369*	0.0553***	0.0553***		
Financial Stress Index	-5.1210***	-5.1148***	0.0991***	0.0675***		
Test critical values						
1%***	-3.465977	-4.008706	0.73900	0.21600	-4.949	-5.347
5% **	-2.877099	-3.434433	0.46300	0.14600	-4.443	-4.859
10% *	-2.575143	-3.141157	0.34700	0.11900	-4.193	-4.607

GMM is used to estimate the vector  $\theta_1 = (c, \delta_1, \beta_{\pi,1}, \beta_{y,1}, \beta_{ciss,1})$  for orthogonality condition (3).  $\theta_2 = (c, \delta_2, \beta_{\pi,2}, \beta_{y,2}, \beta_{ciss,2})$  is the estimated vector for orthogonality condition (8). Here, the information set consists of lagged variables of interest rate, inflation, economic growth and financial systemic stress index that are a part of the  $Z_t$  instrumental variables set and are also uncorrelated with the error terms in equations (7)–(8). As the number of instrumental variables, as well as the moment conditions is more than the dimension of the parameter vector, the model is over-identified and the over-identification restrictions are tested with the J-statistic test.<sup>5</sup>

### 3. Empirical results

#### 3.1. Subsample analysis

The results for the full sample and split sample augmented policy reaction function estimations are shown in Table 3. The first three columns show the estimation results for the contemporaneous rule, while the last three columns give the results for the forward-looking rule. The implied coefficients for inflation, output gap and financial stress are represented by  $\phi_{\pi}$ ,  $\phi_y$ ,  $\phi_{ciss}$  respectively. The p-value of the J-statistic is presented in the last row. In both models the J-statistic p-values imply that the instruments used in the models are valid.

According to the empirical results for the contemporaneous model, the high lagged interest rate coefficient indicates a high level of interest rate smoothing in the CBRT monetary policy for the full sample. Furthermore, the results show that the CBRT is responsive to inflation, but the Taylor (1993) principle is not satisfied,  $\beta_{\pi} < 1.5$ . Moreover, CBRT's sensitivity to the inflation rate is higher than to output gap. Last but not least, the results indicate that there is a statistically significant relationship between systemic financial stress and CBRT policy rates.

The split sample result for the contemporaneous rule gives more insight on the monetary policy responsiveness of the CBRT. We are expecting the CBRT to be more responsive to financial systemic stress in regime II as the financial stability policy is clearly an important feature of the monetary policy framework in this period. The implied coefficients for regime I, shows that the CBRT is responsive to all three variables. Firstly, the interest rate smoothing coefficients in regime I decrease considerably implying a more active monetary policy, which understandable during the financial crisis period. Also, the inflation coefficient is much larger than the

full sample result, while response to the output gap is very close to the full sample finding. Lastly, the lower financial stress coefficient than the full sample coefficient is an expected outcome in terms of *a priori* expectations.

Nonetheless, the empirical findings for regime II differ from regime I noticeably. Firstly; the response of the CBRT to inflation is lower in regime II. The response of policy rates to financial stress is larger in regime II compared to regime I and full sample results. However, it should be noted that the implied coefficient  $\beta_{ciss}$  is lower in the regime II. Even though the CBRT communicates the financial stability goal in this period explicitly; it is hard to know the weight CBRT is giving to financial stability in its monetary policy framework. Hence, if the explicit coefficient is taken as CBRT's real response to financial stress then the CBRT monetary policy regime has indeed shifted to a new policy regime during this period.

The empirical findings for the forward looking rule, confirms the econometric results obtained from the first model. First of all, the full sample results indicate a clearly larger inflation response, while the reaction to output gap increases as well. Here the Taylor (1993) principle is satisfied, which makes sense for an IT implementing central bank. CBRT seems to pay less attention to financial stress in a forward-looking setting compared to the contemporaneous model.

The subsample results for the forward-looking rule show that the CBRT respects its price stability objective during regime I; it was also strong committed to economic activity. There is also sign of responsiveness to financial stress in regime I. In regime II, however the inflation coefficient is much higher, while the CBRT response to output gap is fallen considerably. The findings on the relationship between financial stress and policy rates are similar as in the contemporaneous policy rule. The explicit coefficient is higher in the second regime indicating that the CBRT is more responsive to financial stress compared to the first period.

#### 3.2. Rolling window analysis

As a further analysis to subsample regression, a rolling regression exercise is carried out to compare the monetary rule responsiveness between regime I and II. In this respect, a moving window exercise is carried out with size and step of respectively 20 and 3 months. The results are in favor of the overall subsample estimation results. The results for the ex post rule and forward looking rule are in general in line with each other.

For the interest rate smoothing term, it is obvious that after 2010 interest rate smoothing is lower compared to the first period. On the contrary, inflation responsiveness is rather high in the second period especially until 2014. After this period the CBRT's reaction to inflation seems quite volatile and unstable. Furthermore, CBRT's responsiveness to the output gap has become increasingly stronger

<sup>5</sup> In an exactly identified model (where the number of parameters and moment conditions are equal) the J-statistic is 0, for an over-identified model it is positive. The J-statistic has a chi-square distribution: Where p is the number of instrumental variables and q is the number of parameters estimated. For a given significance level, if the J-statistic is higher than chi-square value the null hypothesis is rejected.

**Table 3**  
GMM estimation results.

	Model (1): $i_t = \delta(i_{t-1}) + C + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - y_t^*) + \phi_{CISS}(CISS_{t-1}) + u_t$ , $\beta_\pi = \frac{\phi_\pi}{1-\delta}$ , $\beta_y = \frac{\phi_y}{1-\delta}$ , $\beta_{CISS} = \frac{\phi_{CISS}}{1-\delta}$			Model (2): $i_t = \delta(i_{t-1}) + C + \phi_\pi(\pi_{t+12} - \pi^*) + \phi_y(y_t - y_t^*) + \phi_{CISS}(CISS_{t-1}) + \varepsilon_t$ , $\beta_\pi = \frac{\phi_\pi}{1-\delta}$ , $\beta_y = \frac{\phi_y}{1-\delta}$ , $\beta_{CISS} = \frac{\phi_{CISS}}{1-\delta}$		
	Full Sample	Regime I	Regime II	Full Sample	Regime I	Regime II
$\delta$	0.930*** (0.008)	0.943*** (0.0044)	0.849*** (0.010)	0.949*** (0.009)	0.955*** (0.006)	0.785*** (0.031)
$\phi_\pi$	0.112*** (0.020)	0.158*** (0.012)	0.140*** (0.033)	0.147*** (0.039)	0.133*** (0.023)	0.684*** (0.120)
$\phi_y$	0.078*** (0.009)	0.059*** (0.003)	0.061*** (0.013)	0.086*** (0.01)	0.086*** (0.007)	0.040*** (0.013)
$\phi_{CISS}$	0.037*** (0.006)	0.017*** (0.003)	0.034*** (0.005)	0.029*** (0.007)	0.023*** (0.004)	0.049*** (0.004)
$\beta_\pi$	1.61	3.16	0.93	2.94	2.95	3.18
$\beta_y$	1.089	1.02	0.40	1.68	1.91	0.19
$\beta_{CISS}$	0.70	0.81	0.26	0.56	0.51	0.22
Adjusted R <sup>2</sup>	0.973	0.984	0.773	0.972	0.980	0.786
Num. of Inst.	36	36	36	36	36	36
J-stat. (P-val)	0.977	0.997	0.996	0.997	0.997	0.996

1)\*, \*\* and \*\*\* indicates significance levels respectively at %10, %5 and %1. The figures in parenthesis are the standard errors.  
 2) 1–12 lagged values of the interest rate; inflation rate and economic activity are used as instrumental variables.  
 3) The estimation weighting matrix is chosen as heteroskedasticity and autocorrelation robust standard errors.

during the period of 2013–2015.

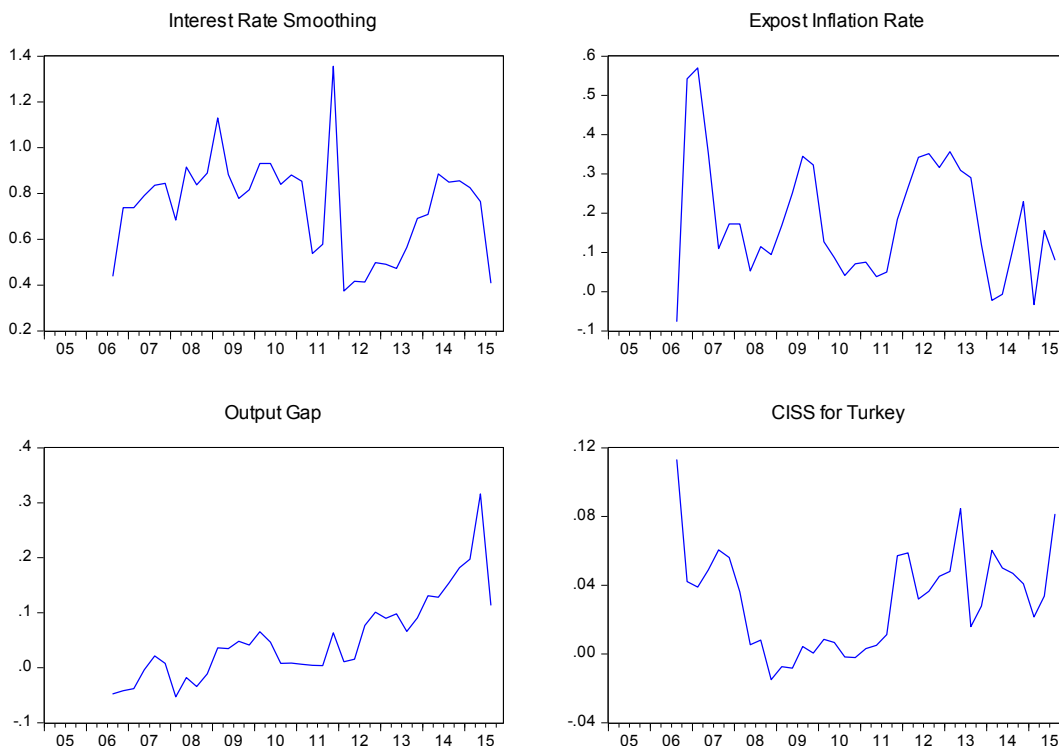
Finally, CBRT’s responsiveness to CISS is displaying an interesting pattern. Before the crisis of 2008, CBRT is showing a strong positive response to an increase in the CISS. However, the response decreases seriously during 2009 and 2010 until mid-2011. Then, the responsiveness of the CBRT increases dramatically between 2012 and 2016 with serious jumps in the data from time to time (Graphs 4 and 5).

3.3. Interaction dummy analysis

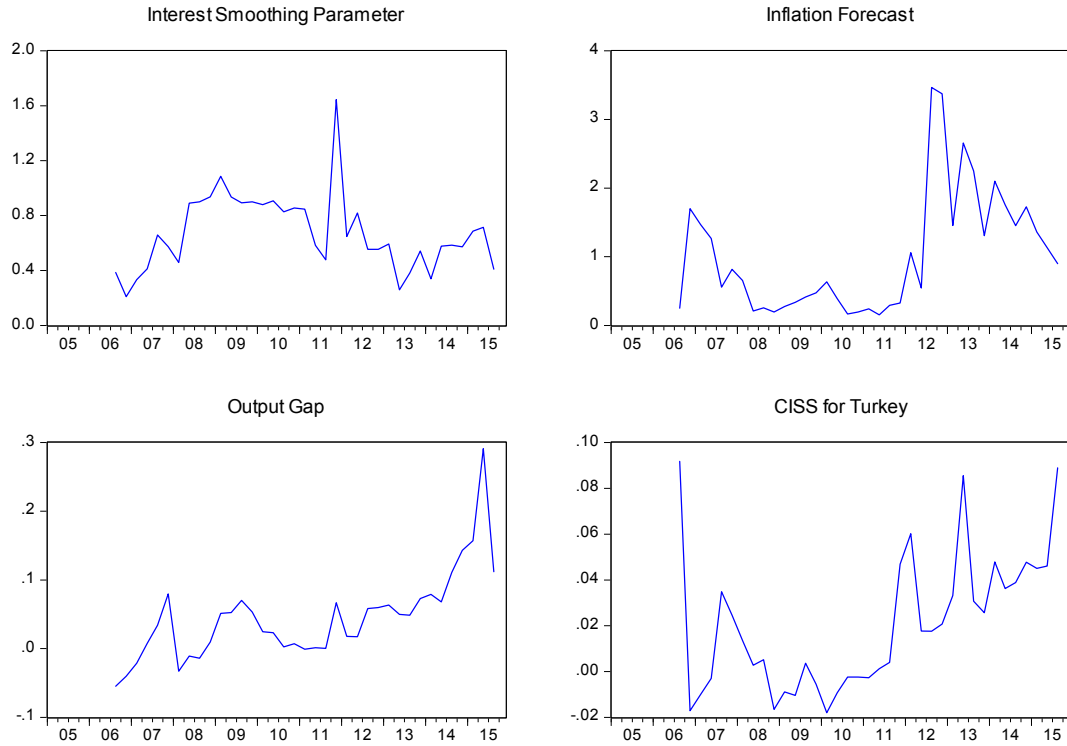
In this analysis, we include a dummy variable,  $D_t$  which is 1 after mid-2010 and 0 for the before for the full sample regression. This dummy is included in the estimation model with its interaction

with output gap, inflation, CISS. By checking coefficients on interaction variables and marginal effects, we want to analyze how the responsiveness to each component has changed over time Table 4.

With the contemporaneous policy rule the dummy is insignificant. Hence, the interaction of it with right-hand side variables seems to result with insignificant coefficients. However, the results for the forward looking policy rule are more promising. The dummy variable is significant and the coefficients of the right-hand side variables are more compatible with subsample forward looking rule results. Inflation responsiveness is significant in the second period, while economic activity is insignificant. Finally, the CBRT is responding to financial stress positively in regime II, while the regression results indicate no relationship in the first period.



**Graph 4.** Rolling Regression with Expost Inflation Rate (Window size 20 months).



Graph 5. Rolling Regression with 12 months Ahead Inflation Forecast (Window size 20 months).

Table 4  
GMM estimation results with interaction dummy.

	Model (3): Contemporaneous Model	Model (4): Forward-looking Model
$\hat{\delta}_1$	0.929*** (0.025)	0.932*** (0.029)
$\phi_{\pi,1}$	0.055 (0.051)	0.009 (0.125)
$\phi_{y,1}$	0.108*** (0.021)	0.096*** (0.030)
$\phi_{CISS,1}$	0.037*** (0.013)	0.033 (0.022)
$\hat{\delta}_2$	-0.196*** (0.093)	-0.422*** (0.127)
$\beta_{\pi,2}$	0.157 (0.100)	1.889*** (0.619)
$\beta_{y,2}$	-0.065** (0.031)	-0.060 (0.041)
$\beta_{CISS,2}$	0.017 (0.021)	0.074*** (0.027)
D	-0.003 (0.503)	-10.680*** (3.935)
Adjusted R <sup>2</sup>	0.971	0.964
Num. of Inst.	36	36
J-stat. (P-val)	0.958	0.987

1)\*, \*\* and \*\*\* indicates significance levels respectively at %10, %5 and %1. The figures in parenthesis are the standard errors.

2) 1–12 lagged values of the interest rate; inflation rate and economic activity are used as instrumental variables.

3) The estimation weighting matrix is chosen as heteroskedasticity and autocorrelation robust standard errors.

#### 4. Conclusion

In this paper, the policy reaction function of the CBRT is augmented with a special financial stress index, i.e. the CISS, and estimated with a GMM approach for the period 2005m1–2015m11. The exercise aims to investigate whether CBRT's policy reaction function to financial stress has changed or not, especially after the policy framework shift in mid-2010. The empirical findings indicate that the CBRT has, indeed, started to lean against financial systemic stress with the regime shift during this period. The sub-sample analysis, where the full sample is divided into two regimes by mid-2010, indicates that the CBRT was more responsive to financial stress in the latter period. The rolling window regression results support our findings of CBRT's higher responsiveness to financial stress after 2010. Although the analysis with interaction dummies is vaguer, the forward looking policy rule results points to

higher CBRT responsiveness after mid-2010 compared to the earlier period.

The unconventional tools that the CBRT used after mid-2010 are practical reflections of CBRT's concern to achieve price and financial stability goals at the same moment. While CBRT kept employing policy rates to sustain overall price stability, it also developed unconventional policy tools such as the policy corridor, reserve requirements and various macroprudential policy measures in order to the mitigate financial stress stemming from volatile currency flows. During this period, CBRT did not dedicate monetary policy to serve both price and financial stability goals. In this sense, it is not easy to trace CBRT's responsiveness to financial stress only through mere monetary policy rule estimation. Further research is essential to account for measuring CBRT's responsiveness to financial stress in terms of macroprudential policy measures.



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