The Interest Rate Channel in Turkey:
An Investigation with Kalman Filter Approach

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ABSTRACT: The monetary authority affects the aggregate demand and investment expenditure via controlling short run interest rates. It is important to satisfy the price stability together with working interest rate channel. This study aims to investigate the validity of interest rate channel in Turkey since the inflation targeting period starting with the year 2002. The sample period covers quarterly data from 1990:1 to 2011:3. It is stated that after the 2002 efficiency of interest rate channel increases.

1. Introduction

The economy policies generally are divided into monetary policy and fiscal policy. While fiscal policy uses the government expenditures and taxes as the instruments, monetary policy uses money supply, short term interest rate, discount rate and etc. However, there are differences of opinion among the economists, i.e,which one is more effective on the economic activity level. Classical economics that is the dominant economic thought up to the Great Depression emhasizes that there is no need any government intervention and economies are in balance. Moreover, any disequilibrium is equalized by the wages and flexible prices.

Following by the classical economic thought, the dominant one is the Keynesian thought in which economies with underemployment are in equilibrium. Keynesian thought stresses that fiscal policy is more effective than monetary policy due to the liquidity trap and zero sensitivity of investment to the interest rates. In the beginning of 1960's monetary thought come on the scene and express that money supply has a fundamental role on determining the economic performance.

If we look over the Turkish economy, up to the 2000 it is seen that monetary pociy is restricted over against expansionary fiscal policy. However folowing by the economic crisis in the 2001, as part of the inflation targeting significant progress toward increasing the independence of executing the monetary policy of central bank has made. In this context, inhibiting the treasury from borrowing short term funds from central bank may be thought as an important development. It indicates that the macroeconomic stability is satisfied both by performing the structural reform and insisting on fiscal discipline together with increasing the applicability of inflation targeting regime. As a result of this macroeconomic stability, it emphasizes that efficiency of central bank gradually increases. So, contrary to the 1990's central bank is more effective for achieving the price stability by using monetary transmission mechanism during this inflation targeting period. Monetary transmission mechanisms that covers the effect of monetary policy to the real macroeconomic variables, such as aggregate supply, unemployment and inflation have been examined through interest rate channel, exchange rate channel, bank credit channel and equity price channel. Beside this, it may be examined

by dividing into two channels so called interest rate and bank credit channels. Following by an expansionary monetary policy, interest rate falls and this causes a rise in investment and GDP at the interest rate channel. At the bank credit side, an expansionary monetary policy increases the the bank reserves and bank deposits together with a rise in quantity of bank loans available. Therefore, this increase will cause investment spending to rise, leading an increase in GDP.

In this study we aim to test the validty of interest rate channel for Turkish economy. Although there are huge number of study dealing with this, most of them use causality tests to validate the monetary transmission mechanisms. However, causality test does not allow to observe the trend of monetary transmission mechanism along the whole time period.

At the interest rate channel known as traditional Keynesian monetary transmission mechanism, effects of interest rate to the the economy are founded on the money market views of Keynes. Keynesian model emphasizes that equilibrium interest rate is determined by money demand and money supply. That is why, interest rate level can be adjusted by monetary policy leading to an increase in investment. However, at the interest rate channel it is stated that a fall in the interest rate causes a rise not only in investment but also in consumption expenditure. The sticky price assumption looms large in this channel. As to this, following by a fall in the short run nominal interest rates, lower interest rates then lead to decrease in short run real interest rates. According to the rational expectation theory, it is agreed that long term real interest rates will be the average of the expected short term interest rates. Therefore, as seen in Figure 1, this fall in long term real interest rates affect the firms's investment and consumption expenditure (Mishkin, 1995; Kutter and Mosser; 2002).

Figure 1. Interest Rate Channel
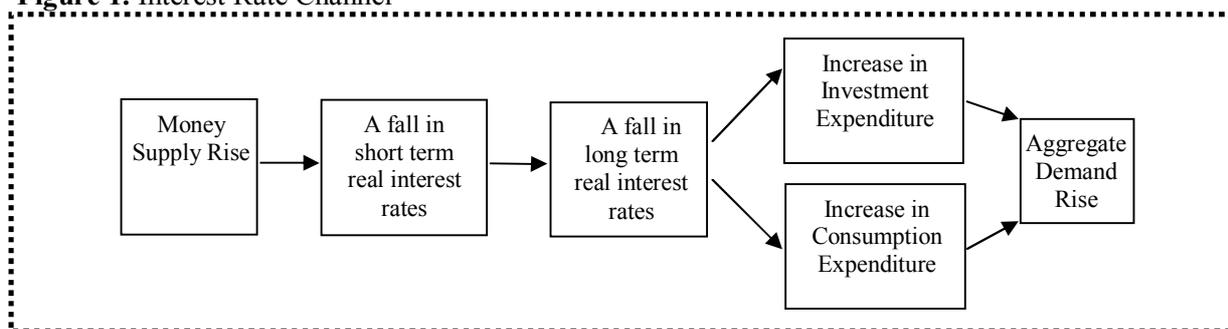
The purpose of this paper is to contribute to the existing literature by analysing the monetary transmission mechanism by using Markov-Switching method and Kalman Filter that allows to observe the effect of inflation targeting regime on interest rate channel in the given period. The paper is organized as follows. Section 1 discusses the theory. Section 2 summarizes the literature. The econometric methods and analysis are presented in Section 3. The overall conclusions are in the final section.

2. Literature Review

Following by Friedman and Schwartz (1963) who denote money supply affecting the real economy, most of the economist agree that monetary policies affect the real economy at least in the short run. However there is no consensus how monetary policy affect the real economy. Thus, there are lots of study resulting several conclusions about monetary transmission mechanisms so called "black box" (Bernanke ve Gertler, 1995, 1). Table 1 presents the summary of this literature review about interest rate channel.

Table 1. Literature review of related works

Author(s)	Countries and Period	Method	Results
Taylor (1995)	Selected OECD Countries (1970-1995)	VAR Analysis	Interest rate elasticity of investment decreases and interest rate eleasticity of consumption decreases especially in USA.
Butzen et al. (2001)	Belgium (1985-1998)	Panel Data Analysis	The contractionary monetary policy causes a fall in firm profit.
Peersman and Smets (2001)	Selected European Countries (1980-1998)	VAR Analysis	A temporary rise in nominal and real short run interest rate, cause a temporary fall in output level.
Angeloni et al. (2002)	Selected European Countries (1971-2000)	VAR Analysis	An unexpected short run interest rate causes a fall in output level after a year.
Sellon (2002)	USA (1972-2000)	Graphical Analysis	The changes in financial system cause a rise in efficiency of monetary policy.
Çiçek (2005)	Turkey (1995:1-2003:2)	VAR Analysis	After a contractionary monetary policy, real production decreases and this will be through in two quarter terms.
Zhang and Sun (2006)	China	General Equilibrium Analysis	The efficiency of interest rates on consumption is limited without credit sector. Therefore, credit sector develops the efficiency of interest rate channel will rise.
Iwata and Wu (2006)	Japan	Non-linear Structural VAR Analysis	When nominal interest rate is zero level, monetary policy shock affects the real economy.
Yue and Zhou (2007)	China (1996:01-2005:08)	Granger Causality Test	There is no causality neither between investment expenditure and the market interest rate nor between household consumption and the market interest rate.
Erdem et al. (2007)	Turkey (1989:1-2005:2)	Kalman Filter Approach	A rise in interest rates cause a fall in output deficit.
Papadamou and Oikonomou (2007)	Selected European Countries (1996:04-2004:04)	VAR Analysis	The interest rates are efficient on industrial production index and interest rate channel works.
Aktaş et al. (2008)	Turkey (2001:07-2008:08)	Regression Analysis	The interest rate channel is efficient via market interest rates.
Büyükakın et al. (2009)	Turkey (1990:01-2007:09)	Causality Tests	A change in interest rates attracts investment, price level and output.
Demary (2010)	10 OECD Countries (1970:1-2005:4)	VAR Analysis	A rise in interest rates cause a fall in output level.
Marius and Angela (2010)	Romania (2000-2009)	Graphical Analysis	After the 2000, efficiency of interest rate channel has risen via structural reforms in the economy especially banking sector.
Sun et al. (2010)	China (1996:1-2008:1)	VAR Analysis	GDP has decreased over against a unit shock of repo rate.
Erdoğan and Yıldırım (2010)	Turkey (1995:01-2008:09)	VAR Analysis	Interest rate channel did not work before the 2002, however it has worked after the 2002.

Abdel-Baki (2010)	Egypt (1991-2009)	Structural VAR Analysis	Following by the reform of banking sector, efficiency of the interest rate channel rises. In addition to this, exchange rate is an another important variable at this point.
Claus (2011)	New Zelland (only one quarter data is used)	General Equilibrium Analysis	The effects of shocks will be higher without using interest rate channel.
Mukherjee and Bhattacharya (2011)	Selected MENA Countries (1990-2009)	Panel Data Analysis	The consumption and investment expenditure are sensitive to interest rates.

3. Econometric Analysis

This part is divided into two sections. First one is econometric method and second one is econometric analysis.

3.1 Method

3.1.1 Markov Switching Model

Markov Switching models were introduced in econometrics by Goldfeld and Quant (1973). Regime switching models are regarded as a promising way to capture nonlinearities in time series. That is mostly true for Markov Switching model in which the probabilities of switching from one regime to another are assumed to be constant in the next period (Maddala& Kim, 1998, 455).

Expansion and recession periods are estimated as to state variable, s_t, that is defined directly and randomly. In regime switching models, s_t is assumed to take integer values, i.e. $s_t = \{1, 2, \dots N \}$. As to N state Markov chain, current regime s_t depends only the s_{t-1}. This implication is given by Equation (1).

$$P\{s_t = j / s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j / s_{t-1} = i\} = p_{ij} \qquad (1)$$

where $\{p_{ij}\}_{i,j=1,2,\dots N}$ gives the state transition probability. Thus, p_{ij} shows the probability of state i following by state j and total probabilities are equal to 1 as seen in Equation (2).

$$pi1 + pi2 + \dots + piN = 1 \qquad (2)$$

The representation of all probabilities in $N \times N$ matrix is given in Equation (3).

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{N1} \\ p_{12} & p_{22} & \cdots & p_{N2} \\ \vdots & \vdots & \cdots & \vdots \\ p_{1N} & p_{2N} & \cdots & P_{NN} \end{bmatrix}, \quad \sum_{j=1}^{N} p_{ij} = 1, \quad i = 1,2,\dots,N, \quad 0 \le p_{ij} \le 1 \quad (3)$$

For the two state case, we have:

$$\hat{\zeta}_{t|t-1} = \begin{bmatrix} P(s_t = 1 | \psi_{t-1}) \\ P(s_t = 2 | \psi_{t-1}) \end{bmatrix} \qquad (4)$$

where $\psi_t = \{\psi_{t-1}, y_t\}$. If $\hat{\xi}_{t-1|t-1}$ is known the regime for t may be estimated by the given information at $t-1$. As to Equation (4) probabilities of yt conditional on st and ψ_{t-1} as a collection in a (2x1) vector are given in Equation (5).

$$\eta_t = \begin{bmatrix} f(y_t | s_t = 1, \psi_{t-1}) \\ f(y_t | s_t = 2, \psi_{t-1}) \end{bmatrix} \qquad (5)$$

The joint probability of yt and st is given by the Equation (6).

$$f(y_t, s_t = j | \psi_{t-1}) = f(y_t | s_t = j, \psi_{t-1}) P(s_t = j | \psi_{t-1}), \quad j = 1,2 \qquad (6)$$

For the two state case, Equation (6) leads to Equation (7). The output $\hat{\xi}_{t|t}$ is calculated by manipulating $\hat{\xi}_{t-1|t-1}$ (Hamilton, 1994).

$$f\left(y_t \middle| \psi_{t-1}\right) = \sum_{s_t=1}^{2} \sum_{s_{t-1}=1}^{2} f\left(y_t \middle| s_t, \psi_{t-1}\right) P\left(s_t \middle| \psi_{t-1}\right) = \eta' \hat{\xi}_{t/t-1} \qquad (7)$$

3.1.2 Kalman Filter Method

Kalman filter method based on the estimation of state- space models is defined with the following equations in which Y_t is dependent variable and X_t is the explanatory variable.

$$Y_t = \alpha_t + \beta_t X_t + \varepsilon_t \qquad t = 1, 2, ..., N \qquad (8)$$

$$\alpha_t = \alpha_{t-1} + n_t \qquad (9)$$

$$\beta_t = \beta_{t-1} + v_t \qquad (10)$$

where α_t is constant, β_t is the coefficient of explanatory variable and ε_t, n_t and v_t are the error terms. Equation (8) represents the observation (or measurement) equation, Equation (9) and (10) represent the state (or transition) equation. This system of equations are given in vector form with Equation (11) and Equation (12) as observation and state equations respectively. The transition equation describes the dynamics of the coefficient Z_t, which is assumed to follow a random walk process.

$$Y_t = \delta' Z_t + \varepsilon_t \qquad (11)$$

$$Z_t = A Z_{t-1} + w_t \qquad (12)$$

where Z_t is the time varying parameters imply $\left(\alpha_t, \beta_t\right)$, δ implies constant term vector and A implies identity matrix, ε_t and w_t are independent error terms. They are assumed to be independent white noise processes. Here, coefficients can change over time and this model allows parameter estimates to respond differently under alternative policy regimes. The model takes into account for the Lucas (1976), Engle and Watson (1987) and Hatemi-J (2002) critiques. As to Lucas (1976), in the policy regimes macroeconomic parameter estimates are not invariant to changes and thus such estimates may be useless for forecasting the impact of the policy changes. In addition changes in the unobservable components of economic variables such as expectations will cause structural change in the data generating process and model misspecification is another justification for using time-varying coefficient (TVC) models. The nonwhiteness of the estimated error terms from the misspecified model can be explained by the changing coefficient values in the TVC model (Hatemi-J and Irandoust, 2008, 620-621).

3.2 Econometric Analysis

3.2.1 Data

The sample period covers quarterly data from 1990:1 to 2011:3. The raw data has been collected from Central Bank of Republic of Turkey (CBRT) and International Financial Statistics (IFS) data bases.

3.2.2 Model

Following by Mukherjee ve Bhattacharya (2010), we agree to use the following models:

$$\text{Model 1:} \left(C/Y\right) = \beta_0 + \beta_1(r) + \beta_2\left(G/Y\right) + \beta_3\left(\Delta Y\right) + \beta_4\left(C_p/Y\right) + \varepsilon_1 \qquad (13)$$

$$\text{Model 2:} \left(I_p/Y\right) = \alpha_0 + \beta_6(r) + \beta_7\left(G/Y\right) + \beta_8\left(\Delta Y\right) + \beta_9\left(C_p/Y\right) + \varepsilon_2 \qquad (14)$$

where β_0 and α_0 are the constants, all $\beta_1, \beta_2, ...\beta_q$ regression coefficients and ε_1, ε_2 are the error terms. In addition Table 2 presents the definition of variables.

Table 2. Variables and Definitions

Variables		Definitions
(C/Y)	:	The ratio of private consumption expenditures over GDP
(G/Y)	:	The ratio of government consumption expenditures over GDP
(C_p/Y)	:	The ratio of aggregate private sector credits over GDP
(I_p/Y)	:	The ratio of private investment expenditure over GDP
(ΔY)	:	Percentage change of the real GDP
(ΔINF)	:	Percentage change of consumer price index
(r)	:	Interbank interest rate

1) Inflation is only used in Markov Switching Method.
2) The variables except interest rate are seasonally adjusted by Tramo-Seats method.
3) Inflation rate data covers from 1988:1 to 2011:4.

3.2.3 Results
3.2.3.1 Unit Root Test
Lee and Strazicich (2003) unit root test results are presented in Table 3. According to the unit root test results, we have found that $(C/Y), (C_p/Y)$, (I_p/Y) and (ΔY) series are stationary in first differences and other series are stationary in levels.

Table 3. Lee-Strazicich Unit Root Test Results

Series	t-stats		Break Points	
			First Break Points	Second Break Points
(C/Y)	-5.50 (3)	-11.89 (0)*	1994:2	2007:2
			2005:3*	2006:4*
(G/Y)	-6.64 (0)		1994:3	2000:1
(C_p/Y)	-5.51 (7)	-9.59 (0)*	2000:1	2005:4
			2001:1*	2007:1*
(I_p/Y)	-4.84 (7)	-6.76 (3)*	2000:3	2005:4
			1997:4*	2007:3*
(ΔY)	-4.32 (8)	-9.49 (3)*	2003:1	2007:4
			1993:3*	1999:2*
(ΔINF)	-8.78 (0)		1993:2	2002:1
(r)	-8.92 (1)		1994:3	2001:2

1) The values within parentheses represent optimal lag lengths for autocorrelation.
2) Critical values at .05 significance level for Lee&Strazicich test are taken from Lee and Strazicich (2003, 1084) for Model C and they are -5.59, -5.74, -5.67,-5.71,-5,65,-5,73 respectively.
3) (*) indicates the t-stats and break points in first diffrences.

3.2.3.2 Markov Regime Switching Method
Markov regime switching method is used to investigate the efficiency of monetary policy interest rate channel in the different inflation periods. Graph 1 presents the estimation results of two regime so called contraction and expansion periods.

Graph 1. Markov Regime Switching Method Results
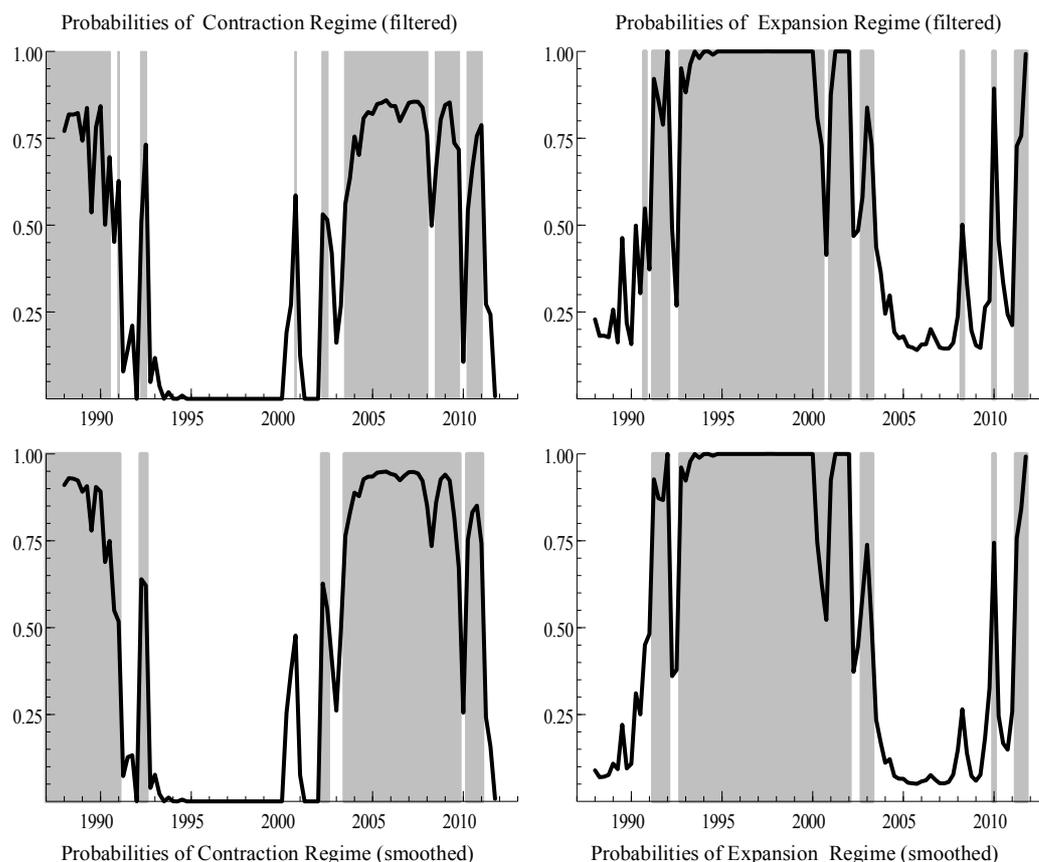
According to the results in Graph 1, probabilities, number of observations corresponding to the related periods are presented in Table 4.

Table 4. Regime Properties and Transition Matrix

Transition Matrix		
Regime	Contraction	Expansion
Contraction	0.50125	0.12820
Expansion	0.49875	0.87180
Regime Properties				
Regime	**Number of Observations**	**Periods**	**Average Probabilities**	**Average Durations**
Contraction	13	1988:1 - 1991:1	0.813	9.40 quarter
	2	1992:2 – 1992:3	0.630	
	2	2002:2 – 2002:3	0.590	
	26	2003:3 – 2009:4	0.894	
	4	2010:2 – 2011:1	0.795	
Expansion	4	1991:2 – 1992:1	0.917	9.80 quarter
	38	1992:4 – 2002:1	0.965	
	3	2002:4 – 2003:2	0.613	
	1	2010:1 – 2010:1	0.745	
	3	2011:2 – 2011:4	0.864	
Linearity LR-test Chi^2(4) = 43.518 (0.0000)* approximate upperbound: (0.0000)*				

Note: The likelihood ratio (LR) test implementing the upper bound of Davies (1987) also suggests that all models reject the null of linearity at the .01, .05 and .10 significance levels and certify the use of regime-switching models.

Table 4 shows that after the inflation targeting regime probabilities of contraction increase also during (2003:3-2009:4) period. This result also indicates that monetary policy is efficient to control high inflation most of inflation targeting period which starts at January 2002.

3.2.3.2 Kalman Filter Method

Kalman Filter Method needs stationary variables so variables used in the analysis are all stationary. Here crisis dummies are d1, d2 and d3 are for the years 1994, 2001 and 2008 respectively. Kalman filter method is used to determine the paramaters which are chanching over the time. And we also expect that interest channel is more efficient during the inflation targeting regime. In other words, the values of the β_1 and β_6 is becoming high after the inflation targeting regime is adopted by the Central Bank of Turkey. So we have performed the Kalman Filter method, and showed the results in Graph 2 and 3.

Graph 2. Kalman Filter Method Results (Model 1)
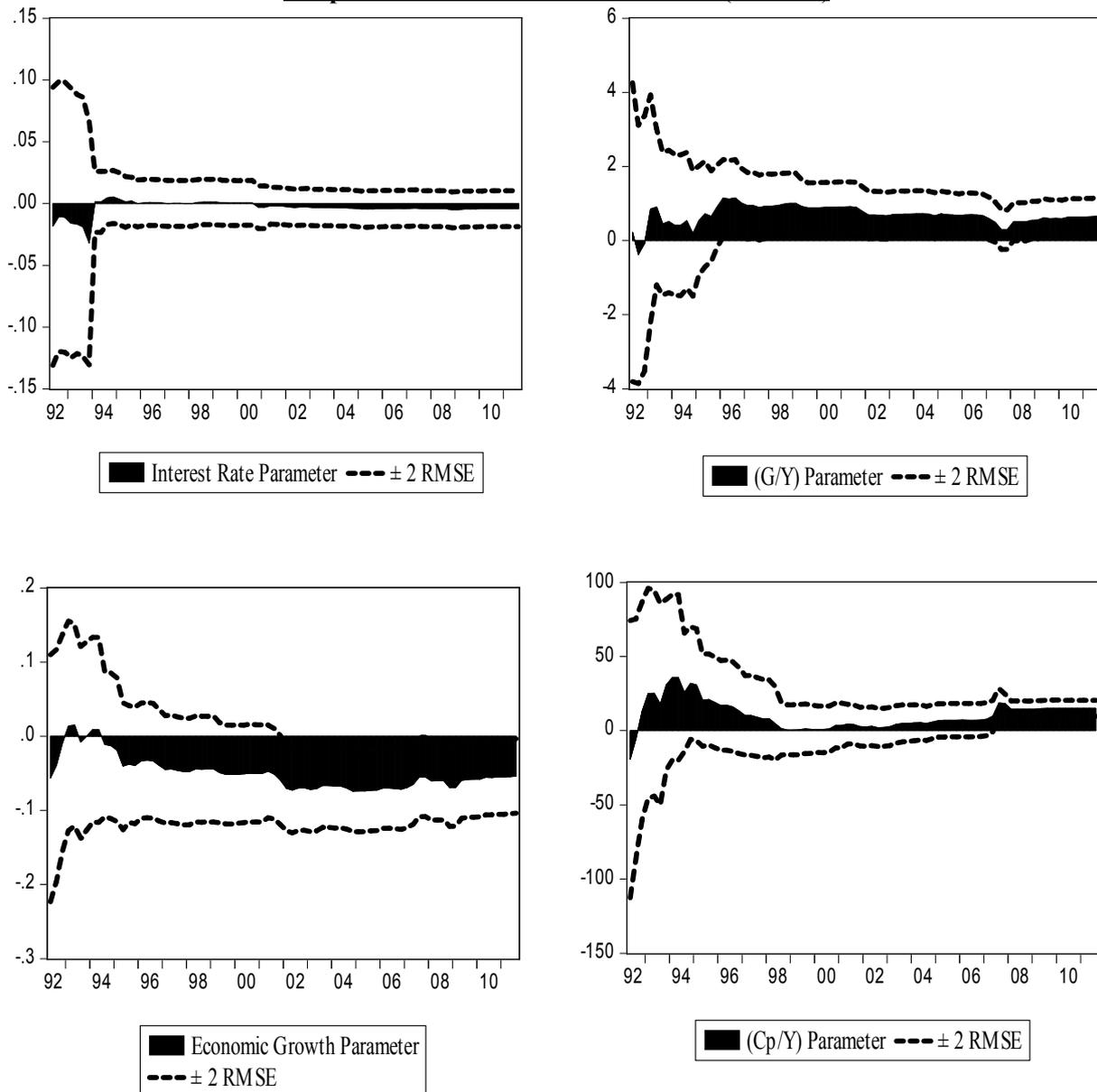
When we analyze Kalman Filter method results, we have seen that interest rate effects consumption and investment expenditures negatively. Especially, as can be seen in Graph 3, the effect of interest rate on consumption expenditures undergone a sharp change during inflation targeting period.

Graph. 3 Kalman Filter Method Results (Model 2)
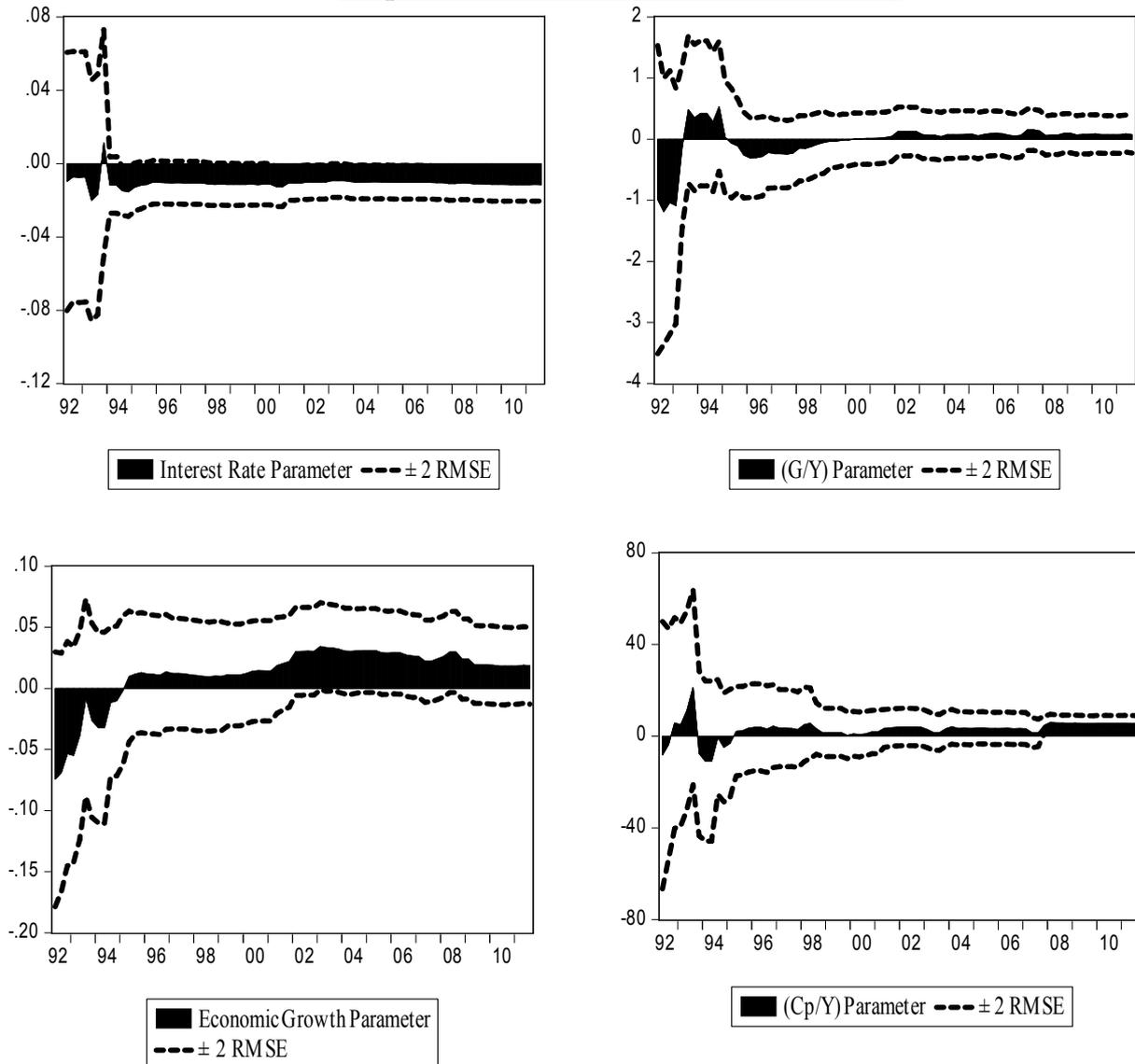
4. Conclusions

While the Central Bank of Republic of Turkey implements implicit inflation targeting from 2002 to 2006, from 2006 to present explicit inflation targeting has been implemented. Following by the inflation targeting regime practice, it is observed that a noticeably decrease in the inflation level occurs. It is approximately 70.01 % and 11.6 % in the 1983-2001 and 2002-2011 periods respectively. This case indicates that inflation targeting regime is an effective monetary policy instrument. The efficient monetary policy means monetary transmission mechanism works well.

This study aims to investigate the economic influences of the inflation targeting regime on the interest rate channel. Results show that inflation targeting regime is effective not only on decreasing the inflation rates but also on increasing the performance of interest rate channel. In other words, Central Bank is effective on both consumption and investment expenditure in the inflation targeting regime period. Especially, it is stated that its ability on controlling the consumption expenditure increases.

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