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RESEARCH ARTICLE

Measuring the impacts of monetary policy in Turkey: an extended structural vector autoregressive model with structural breaks

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Abstract
The goal of this paper is to measure the impacts of monetary policy shocks in Turkey using monthly data spanning the period 2011:M01–2021:M12. To that end, the paper extends the structural vector autoregressive (SVAR) methodology with structural breaks. The findings show that a positive monetary policy shock, namely an increase in interest rates, results in a decrease in consumer prices and the exchange rate. The findings also exhibit that a positive shock in the exchange rate, namely the depreciation of the TRY against foreign currencies, increases interest rates and consumer prices. The implications of these findings in terms of monetary policy in Turkey are discussed in the paper.

Keywords Monetary policy · The Central Bank of the Republic of Turkey · Structural VAR analysis · Structural breaks · Control horizon · Exchange rate pass-through

JEL Classification C32 · E52 · E58 · F41

Introduction

When one examines the debates on economic policy over the last decades, he/she can notice that three issues become prominent. First, monetary policy has been at the forefront of economic policy, especially in times of crises [3]. Second, financial instruments that were produced in the 1980s and the high volatility in the velocity of circulation, respectively, weakened the control of the money supply by central banks and the relationship between monetary aggregates and inflation [45]. Hence, most central banks have conducted monetary policy by essentially adjusting short-term

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interest rates in money markets [34]. Within this scope, the transmission of monetary policy begins with the money markets, and the impacts of monetary policy are transmitted through monetary transmission channels, i.e., the interest rate channel, the exchange rate channel, the asset price channel, and the credit channel, etc. [44]. Third, many central banks have implemented monetary policy under the inflation-targeting regime since it was first adopted by the Reserve Bank of New Zealand in 1990. Put differently, many central banks around the world have used an inflation target to define their monetary policy frameworks [51]. As Morozumi et al. [47] state, 39 central banks in the world adopt the inflation targeting strategy currently. Additionally, the monetary policy frameworks of the Federal Reserve (FED) and the European Central Bank (ECB) resemble the inflation-targeting regime even though they do not explicitly state it [22]. For this reason, there exists an almost global consensus on the implementation of monetary policy under the inflation-targeting regime in the world. Under inflation targeting, a central bank tries to minimize the loss function which implies the central bank tries to achieve the inflation target and decrease the deviation of GDP from potential GDP [53]. Hence, the central bank whose primary objective is to achieve and maintain price stability also tries to minimize the output gap. Within this scope, while the monetary policy reaction functions suggested by Taylor [54] and Clarida et al. [16] include output and inflation, some studies in the extant literature extend the reaction functions of central banks with financial variables and examine whether the central banks responded to these variables (see e.g., [14, 40, 41, 43], among others).

Monetary policy in Turkey has exhibited a very dynamic characteristic over the last decades. For instance, after the implicit inflation targeting strategy endorsed over the period 2002–2005, the Central Bank of the Republic of Turkey (CBRT) adopted the inflation targeting strategy in 2006. Afterward, in October 2010, the CBRT extended the monetary policy framework and declared that it would try to achieve not only price stability but also financial stability because of the appreciation of the domestic currency (TRY) against foreign currencies and the rapid credit growth in Turkey. Additionally, the CBRT began to implement some macroprudential tools, such as the asymmetric interest rate corridor, the required reserves ratio, and the reserve option mechanism.[1] Besides, monetary policy of the CBRT was highly complicated until May 2018. As Apergis et al. [4] denote, there existed high uncertainty for banks about the lending rates of the CBRT. Accordingly, the CBRT lent banks at the 1-week policy rate, the overnight lending rate, and the late liquidity window facility, meaning the borrowing rates for banks frequently changed. Then, in May 2018, the CBRT announced that it simplified the monetary policy framework and would lend to banks at the 1 week policy rate as it was before.

This paper focuses on monetary policy in Turkey and examines the dynamic impacts of monetary policy shocks in Turkey using monthly data covering the period 2011:M01–2021:M12. Within this frame, a positive monetary policy shock (an increase in short-term interest rates) and a negative monetary policy shock (a

[1] See Kara [36] and Varlik and Berument [57] for a detailed explanation of the CBRT's monetary policy in this period.

decrease in short-term interest rates), respectively, refer to contractionary and expansionary monetary policy in the paper. As is clearly expressed in the previous literature, small open economies are usually price-takers from world markets and are more sensitive to developments in the world [33, 38, 55]. Therefore, considering Turkey can be affected by the developments in the world, the paper employs the structural vector autoregressive (SVAR) approach with a block exogeneity assumption of Cushman and Zha [19]. This approach classifies the variables in the SVAR model into two groups: domestic variables and external variables. Block exogeneity postulates that while external variables can have effects on domestic variables, domestic variables do not have any impacts on external variables. Besides, the use of block exogeneity decreases the number of estimated parameters and lets the central bank's monetary policy reaction function includes external variables.

How this paper contributes to the monetary economics literature lies in the following points: First, understanding the transmission of monetary policy is of great importance to making policy decisions and assessing macroeconomic models [42]. However, little is still known about when and how a change in monetary policy affects macroeconomic variables [8, 11]. In his seminal papers, [28–30] expresses that monetary policy affects the economy after a lag that is long and variable, implying there exist monetary transmission lags. Besides, as Blinder [10] states, there is model uncertainty for the monetary policy transmission which means there is no consensus among economists and central bankers regarding the right model and the right econometric techniques. Therefore, this paper provides fresh empirical evidence about the monetary transmission lags in Turkey. Second, as the CBRT tries to pursue financial stability along with price stability, this paper also tests whether the monetary policy of the CBRT influences asset prices (exchange rate and stock market index) in Turkey. Third, this paper examines the magnitude of exchange rate pass-through (ERPT) to domestic prices in Turkey. The ERPT process is highly important for small open economies as they are more vulnerable to international transmission of shocks. Last but not least, economic variables are exposed to different forms of structural breaks, meaning a researcher can obtain inefficient findings if he/she ignores these breaks [5]. Additionally, some variables demonstrate a wide variety of structural breaks of unknown numbers and forms [7]. Hence, differing from the previous studies that examine the impacts of monetary policy shocks in Turkey through the SVAR approach with a block exogeneity assumption, this paper extends the SVAR analysis with the structural breaks. The reason why the paper considers structural breaks is that monetary policy in Turkey had a highly dynamic feature in terms of monetary policy goals and tools in the last years as we explain above. Besides, the paper takes endogenous structural breaks into account through the Fourier approximation instead of capturing exogenous structural breaks using dummy variables. Hence, a key strength of this paper is that it is the first paper that takes endogenous structural breaks into account while modeling the impacts of a monetary policy shock on macroeconomic variables in Turkey.

The rest of the paper is organized as follows: "Brief literature" gives the empirical literature about the impacts of monetary policy shocks in Turkey. "Data set" introduces the data set. "Methodology" provides the estimation methodology. Estimation results are exhibited in "Results". "Conclusion" concludes the paper.

Brief literature

The VAR approach is the main econometric methodology that is employed to examine the effects of monetary policy shocks in the empirical literature [34]. Within this scope, some papers have examined the impacts of a monetary policy shock in Turkey through the VAR methodology. This paper classifies the papers focusing on the impacts of monetary policy shocks through the VAR method into two groups.

The first group examines the effects of monetary policy shocks via the conventional VAR approach. For instance, Berument [9], using data over the period 1986–2000, yields that a contractionary monetary policy leads to a decrease in income and prices and an appreciation in the TRY. He also discovers that the impact of contractionary monetary policy is permanent for prices and the exchange rate and is transitory for income. Erdoğan and Yıldırım [25] utilize data for the period 1995–2007 and explore that an increase in interest rates results in a decrease in expenditures for durable goods and gross fixed capital formation. Örnek [48] reveals that an increase in interest rates decreases output and increases inflation through data over the period 1990–2006. Cambazoğlu and Güneş [12] use data over the period 2003–2010 and find that an increase in interest rates reduces prices, but it has no significant effect on output.

The second group investigates the impacts of monetary policy shocks through the SVAR analysis. Accordingly, Akbaş et al. [1], employing data for the period 2005–2013, discover that an increase in interest rates increases industrial production. Kılınç and Tunç [37] explore that an increase in interest rates decreases output and prices and leads to the appreciation of the TRY using data spanning the period 2006–2013. Can et al. [13] use data over the period 2006–2018 and discover that a positive monetary policy shock results in a decrease in output and prices. Finally, Yıldırım [62], using data for the period 2011–2020, explores that an increase in interest rates leads to a decrease in prices and an appreciation of the TRY.

As is seen from the extant monetary economics literature, none of the previous papers has considered structural breaks while modeling the impacts of a monetary policy shock on macroeconomic variables. Hence, we would like to remind you that this is the first paper that takes structural breaks into account while examining the effects of a monetary policy shock in Turkey.

Data set

Following a time series analysis to measure the impacts of a monetary policy shock in Turkey, this paper uses monthly data covering the period 2011:01–2021:12. As this paper performs an SVAR methodology with the assumption of block exogeneity, it uses two types of variables: domestic variables and external variables. Domestic variables are the short-term interest rate

Table 1 Data set

Variable	Abbreviation	References
Interest rate	IR	CBRT [15]
Industrial production index	lnIP	CBRT [15]
Consumer price index	lnCPI	CBRT [15]
Exchange rate	lnEXC	CBRT [15]
Stock market index	lnSMI	CBRT [15]
Oil prices	lnOILP	US Energy Information Administration [56]
US industrial production index	lnUSIP	Federal Reserve Bank of St. Louis [27]
US shadow rate	SR	Wu and Xia [59]

(the overnight weighted average interest rate at the Borsa Istanbul Interbank Repo/Reverse Repo Market), the seasonally adjusted industrial production index (2005 = 100), the consumer prices index (2003 = 100), the exchange rate basket that is constituted 0.5 USD and 0.5 Euro,[2] and the stock market index (BIST 100 Index, 1986 = 1). The external variables are oil price (Europe Brent Spot Price FOB, USD per barrel), the US seasonally adjusted industrial production index (2017 = 100), and the shadow rate in the USA. Oil is a considerable commodity for production and Turkey is an oil-importing country. Hence, we use oil price as an indicator for world commodity prices considering oil prices may have effects on the Turkish economy. As the USA is the greatest economy in the world and the developments in the US economy can have serious effects on the rest of the world, the paper uses US industrial production index as a proxy for external demand. Finally, we use the shadow rate instead of the federal funds rate as the shadow rate considers quantitative easing policies of the FED in the zero lower bound environment and thus better reflects the monetary policy stance of the FED. All variables except the interest rate and the shadow rate are used in their natural logarithmic forms described by ln. Data for the interest rate, the industrial production index, the consumer price index, and the exchange rate are obtained from the CBRT [15]. While data for oil prices are extracted from the US Energy Information Administration [56], data for the US industrial production index are received from the Federal Reserve Bank of St. Louis [27]. Finally, data for the US shadow rate are obtained from Wu and Xia [59]. Table 1 demonstrates the variables under consideration.

[2] In this paper, an increase in the exchange rate means a depreciation of the TRY against foreign currencies.

Methodology

The VAR models have been employed in macroeconomics since the pioneering study of Sims [50]. A first-order bivariate VAR model can be described as follows [23]:

$$y_t = \alpha_{10} - \alpha_{12} z_t + \beta_{11} y_{t-1} + \beta_{12} z_{t-1} + \varepsilon_{yt} \tag{1}$$

$$z_t = \alpha_{20} - \alpha_{21} y_t + \beta_{21} y_{t-1} + \beta_{22} z_{t-1} + \varepsilon_{zt} \tag{2}$$

where y and z are endogenous stationary variables, and ε_{yt} and ε_{zt} are white-noise disturbances.

One needs to consider two issues for a VAR model. First, the standard VAR model does not take structural breaks, i.e., wars, economic crises, radical changes in economic policies, etc., into account, whereas structural breaks can affect the relationships between variables in the VAR model. Second, when there are more than two variables and the optimal lag length of the system is more than unity, there will be many parameters that will be estimated. The former issue can be handled by considering structural breaks through the Fourier approximation while the latter issue can be addressed by employing the SVAR methodology. Accordingly, we first extend the standard VAR model in Eqs. (1–2) with structural breaks. Thus, we believe that we can capture structural breaks in the VAR model. In this notation, we add breaks to the VAR model as exogenous variables. The extended VAR model with a single frequency can be stated as

$$y_t = \alpha_{10} - \alpha_{12} z_t + \beta_{11} y_{t-1} + \beta_{12} z_{t-1} + \delta_{11} \sin(2\pi kt/T) + \delta_{12} \cos(2\pi kt/T) + \varepsilon_{yt} \tag{3}$$

$$z_t = \alpha_{20} - \alpha_{21} y_t + \beta_{21} y_{t-1} + \beta_{22} z_{t-1} + \delta_{21} \sin(2\pi kt/T) + \delta_{22} \cos(2\pi kt/T) + \varepsilon_{zt} \tag{4}$$

where k is the particular frequency and T is the number of observations. Using matrix algebra, one can redefine the extended VAR model as the following:

$$\begin{bmatrix} 1 & \alpha_{12} \\ \alpha_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix} \begin{bmatrix} \sin(2\pi kt/T) \\ \cos(2\pi kt/T) \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

$$Bx_t = \psi_0 + \psi_1 x_{t-1} + \psi_2 f_t + \varepsilon_t \tag{5}$$

where $B=\begin{bmatrix} 1 & \alpha_{12} \\ \alpha_{21} & 1 \end{bmatrix}$, $x_t=\begin{bmatrix} y_t \\ z_t \end{bmatrix}$, $\psi_0=\begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix}$, $\psi_1=\begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}$, $\psi_2=\begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix}$,

$$ft = \begin{bmatrix} \sin(2\pi kt/T) \\ \cos(2\pi kt/T) \end{bmatrix}, \varepsilon t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

To obtain the VAR model in the standard form one can multiply Eq. (5) with B^{-1}:

$$x_t = A_0 + A_1 x_{t-1} + A_2 f_t + e_t \tag{6}$$

where $A_0 = B^{-1}\psi_0, A_1 = B^{-1}\psi_1, A_2 = B^{-1}\psi_2$, and $e_t = B^{-1}\varepsilon_t$.

Second, we employ the SVAR methodology and impose some restrictions on the VAR model. The reason why we perform the SVAR approach instead of the Cholesky decomposition is that the Cholesky decomposition is highly sensitive to the order of variables. However, SVAR models can establish relationships between variables based on economic theory according to the open economy framework [2]. The identification structure of an SVAR model lets variables contemporaneously respond to other external or domestic variables [37]. Cushman and Zha [19] clarify the transformation of a VAR model into an SVAR model with block exogeneity using the following equations[3]:

$$A(L)y(t) = \varepsilon(t) \tag{7}$$

where $y(t)$, $A(L)$, and $\varepsilon(t)$, respectively, stand for an mx1 vector of observations, an $m \times m$ matrix polynomial in the lag operator, and an $m \times 1$ vector of structural disturbances or shocks. Then, the matrices can be described as

$$y(t) = \begin{bmatrix} y_1(t) \\ y_2(t) \end{bmatrix}, A(L) = \begin{bmatrix} A_{11} & A_{12}(L) \\ 0 & A_{22}(L) \end{bmatrix}, \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix}$$

The restriction $A_{21}(L) = 0$ stems from the block exogeneity assumption and means that the domestic variables have no impact on the external variables.

If the reduced form of the SVAR model is defined as $B(L)y(t) = u(t)$, then the structural shocks are associated with the reduced form of the residuals that are obtained from the SVAR model and are denoted as below [37]:

$$\varepsilon(t) = A_0 u(t) \tag{8}$$

The next step for the SVAR analysis is to establish the relationships between shocks. Then, our identification scheme in the paper can be described as follows:

$$\begin{bmatrix} \varepsilon_{IR_t} \\ \varepsilon_{\ln IP_t} \\ \varepsilon_{\ln CPI_t} \\ \varepsilon_{\ln EXC_t} \\ \varepsilon_{\ln SMI_t} \\ \varepsilon_{\ln OILP_t} \\ \varepsilon_{\ln USIP_t} \\ \varepsilon_{SR_t} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & a_{14} & a_{15} & 0 & 0 & a_{18} \\ 0 & a_{22} & a_{23} & 0 & 0 & a_{26} & 0 & 0 \\ 0 & 0 & a_{33} & a_{34} & 0 & a_{36} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} & a_{47} & a_{48} \\ a_{51} & 0 & 0 & 0 & a_{55} & 0 & 0 & a_{58} \\ 0 & 0 & 0 & 0 & 0 & a_{66} & a_{67} & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{76} & a_{77} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_{88} \end{bmatrix} \begin{bmatrix} u_{IR_t} \\ u_{\ln IP_t} \\ u_{\ln CPI} \\ u_{\ln EXC_t} \\ u_{\ln SMI_t} \\ u_{\ln OILP_t} \\ u_{\ln USIP_t} \\ u_{SR_t} \end{bmatrix}$$

Our identification structure lets one variable respond to domestic and external variables contemporaneously. Besides, the block exogeneity assumption, $A_{21}(L) = 0$, implies external variables do not react to domestic variables. Accordingly, we

[3] See Cushman and Zha [19] for the details of the SVAR methodology with block exogeneity.

impose the following restrictions: (i) As monetary policy has a lagged effect on output and inflation, a central bank will consider the expected inflation and expected output [17, 52]. Hence, interest rates in Turkey can contemporaneously be affected by financial variables, such as the exchange rate, the stock market index, and the shadow rate, considering the reaction function of the CBRT may include these variables along with expected inflation and expected output. Besides, we posit that no variables in the system have a concurrent effect on the shadow rate. (ii) Barnett et al. [6] argue that real economic activities respond to domestic prices and financial variables with a lag, whereas they are affected by a shock in the world. Following Barnett et al. [6], we believe that oil prices may have a concurrent impact on industrial production. However, differing from Barnett et al. [6], we argue that domestic prices can have an immediate effect on industrial production in Turkey, where the inflation rate and inflation uncertainty are very high in the last periods.[4] (iii) Domestic prices can be contemporaneously affected by the exchange rate as ERPT to domestic prices appears to be immediate and high in Turkey (see e.g., [55]. Besides, imported inputs in the manufacturing industry and the sensitivity of domestic prices to external shocks have increased in Turkey in the last years [26]. Hence, oil prices can influence domestic prices in Turkey. (iv) Following Cushman and Zha [19], Kılınç and Tunç [37], Barnett et al. [6], Venter [58], and Yıldırım [62], we postulate that all domestic and external variables have a contemporaneous impact on the exchange rate. (v) The literature posits that the stock market is forward-looking for an economy, meaning expectations about future economic activities affect stock prices [18]. Hence, current economic activities do not immediately influence stock prices. Additionally, Yang and Doong [60] find evidence for G7 countries that the stock market influences the exchange rate, but not vice versa. They argue that the reason for this finding is that the rapid integration and deregulation of financial markets resulted in intense capital flows across borders. The empirical findings of Iltas and Bulut [35] for the Turkish economy concur with those of Yang and Doong [60]. Hence, we suppose that the exchange rate has no contemporaneous impact on the stock market index. However, the monetary policy stances of the CBRT and the FED can contemporaneously affect the stock market index. (vi) As per World Bank [63] data, the share of US GDP in the total world GDP was 23.58 percent in 2020. Hence, we postulate that the US economy, which is the greatest economy in the world, may affect oil prices, meaning oil prices can be affected by industrial production in the USA concurrently. Besides, oil prices may have an immediate impact on industrial production in the USA as oil is a considerable input for the manufacturing industry. Put differently, we believe that the US industrial production index and oil prices may influence each other contemporaneously.

[4] See Apergis et al. [4] to observe how high inflation creates high inflation uncertainty in Turkey.

Table 2 Unit root tests

Variable	ADF test statistic		PP test statistic		KPSS test statistic	
	Level	1st dif	Level	1st dif	Level	1st dif
IR	−2.270	−6.255*	−2.069	−6.209*	0.817*	0.039
lnIP	−1.548	−20.546*	−2.188	−56.089*	1.354*	0.169
lnCPI	2.839	−3.885*	3.524	−3.674*	1.407*	0.131
lnEXC	2.021	−6.590*	2.236	−5.052*	1.396*	0.063
lnSMI	−0.291	−11.572*	0.595	−12.717*	1.260*	0.266
lnOILP	−1.963	−9.083*	−1.849	−9.049*	0.749*	0.109
lnUSIP	−2.564	−9.630*	−2.537	−9.875*	0.841*	0.093
SR	−1.325	−4.833*	−1.221	−8.344*	0.609**	0.206

*$p \leq 0.01$

**$p \leq 0.05$

Source: the author

Results

For an SVAR analysis, all variables under consideration must be stationary. Hence, we first investigate the stationarity levels of variables in this paper. The present paper employs the ADF test of Dickey and Fuller [21], the PP test of Phillips and Perron [49], and the KPSS test of Kwiatkowski et al. [39] to determine the order of integration of the variables. While the ADF and PP methods test the null hypothesis of a unit root, the KPSS technique tests the null hypothesis of stationarity.

The results of the unit root test are reported in Table 2. As is seen, for the ADF and PP tests, the null hypothesis of a unit root cannot be rejected at level, whereas it is rejected at the first difference. Hence, these tests yield that all variables are integrated into order one. Additionally, the null hypothesis of stationarity is rejected at level, while it cannot be rejected at the first difference with regard to the KPSS test. Therefore, the KPSS unit root test explores that all variables are integrated of order one just like the ADF and PP tests discover. Overall, the results of the unit root tests indicate that all variables must be included in the SVAR model at their first differences. Hence, we consider the first difference forms for all variables while conducting the SVAR analysis.

Before presenting the impulse-response functions for the SVAR analysis, we, respectively, detect the optimal lag length without serial correlation for the model, estimate the SVAR model based on the optimal lag length, and examine whether the SVAR model satisfies the stability conditions. After making the parameter estimations and discovering the model is stable,[5] the paper demonstrates the results of the impulse-response functions. The impulse-response analysis exhibits the reaction of a variable to a shock to another variable in the VAR/SVAR model. The reactions of the variables in the model to one positive standard deviation shock to interest rates,

[5] These results are not exhibited here to save space, but they are available upon request.

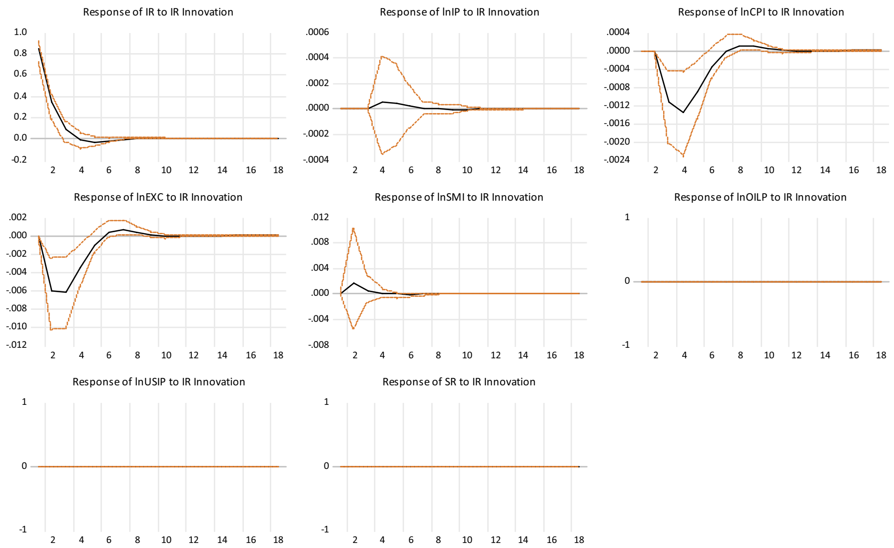

Fig. 1 Impulse-response analysis for a positive interest rate shock in the SVAR model

namely a tightening in monetary policy, are depicted in Fig. 1. Put differently, Fig. 1 shows the interest rate channel for the Turkish economy. As is seen, contractionary monetary policy represented by one positive standard deviation shock in interest rates increases industrial production. However, the impact of this shock is statistically insignificant. Besides, a positive shock in interest rates leads to an immediate decrease in the price level and the exchange rate. The impact of this shock, respectively, continues for 10 and 9 months for the price level and the exchange rate. Accordingly, contractionary monetary policy not only decreases the price level but also leads to the appreciation of the TRY against foreign currencies. These findings can also be found in Berument [9], Kılınç and Tunç [37], and Yıldırım [62]. Cushman and Zha [19] point out that an increase in interest rates leads to an increase in the price level (the price puzzle) and depreciation of the domestic currency (the exchange rate puzzle) for many countries. However, this paper yields empirical findings which are consistent with the economic theory, implying the appropriate identification structure is used in the paper. Figure 1 also reports that the stock market index is not affected by an increase in interest rates in Turkey. Finally, the contractionary monetary policy in Turkey does not influence oil prices, US industrial production, and the shadow rate. This finding is consistent with our identification structure in which domestic variables do not affect external variables, i.e., the block exogeneity assumption.

The responses of the variables in the model to one positive standard deviation shock to the exchange rate are depicted in Fig. 2. In this paper, an increase in the exchange rate implies the depreciation of the TRY against foreign currencies by

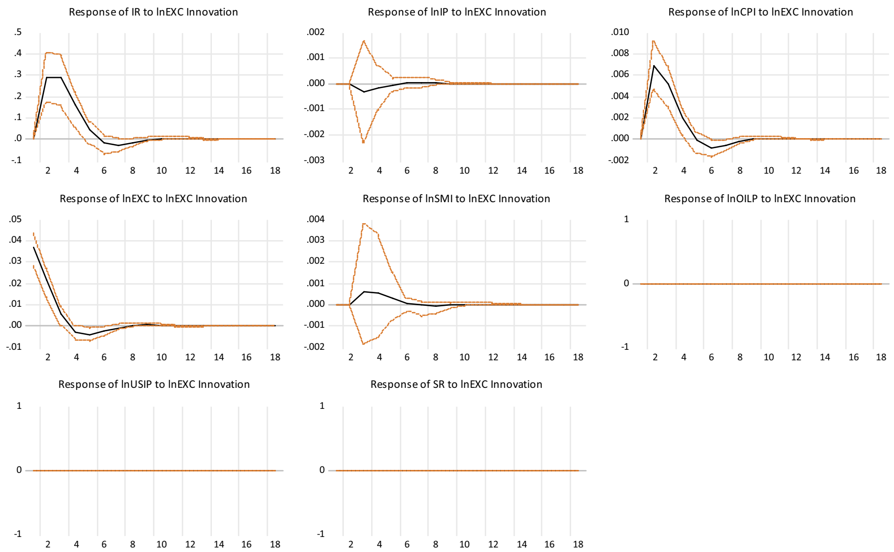

Fig. 2 Impulse-response analysis for a positive exchange rate shock in the SVAR model

definition. Accordingly, a positive shock in the exchange rate results in an increase in interest rates in Turkey. This finding implies that the monetary policy reaction function and the loss function of the CBRT include the exchange rate. This finding is compatible with the papers of Erdem et al. [24] and Dağlaroğlu et al. [20]. Additionally, the price level in Turkey appears to rapidly increase against an increase in the exchange rate. As is seen, the impact of one positive standard deviation shock to the exchange rate on the price level continues throughout 8 months and then becomes insignificant. Furthermore, the shocks in the exchange rate decrease industrial production and increase the stock market index, whereas the effects of these shocks are not statistically significant. Finally, oil prices, US industrial production, and the shadow rate do not respond to the exchange rate shock by the block exogeneity assumption.

Some recent papers in the extant literature find evidence in favor of a strong ERPT process in Turkey through different estimation methodologies. For instance, Tunc and Kilinc [55], Gayaker et al. [32], and Yilmaz and Yucel [61], respectively, employ the SVAR analysis, the threshold regression methodology, and the nonparametric Kernel estimation and yield there exists sizeable ERPT to domestic prices in Turkey. Hence, this paper also presents the cumulative responses of the price level to a positive exchange rate shock to reveal the pass-through coefficient. Accordingly, Fig. 3 plots the magnitude of the ERPT process in Turkey. As is seen, the employed SVAR model indicates 1.2 percent ERPT to consumer prices and this effect occurs

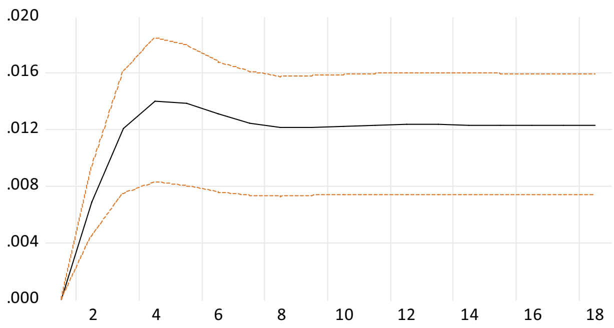

Fig. 3 The magnitude of ERPT to consumer prices in Turkey

in around 8 months. Hence, the findings of this paper concur with those of Tunc and Kilinc [55], Gayaker et al. [32], and Yilmaz and Yucel [61], who previously found ERPT was a considerable factor in the high inflation rates in Turkey.[6]

Conclusion

This paper has examined the effects of monetary policy shocks in Turkey using monthly data spanning the period 2011:M01–2021:M12. The paper first constructed the SVAR model with the block exogeneity assumption propounded by Cushman and Zha [19]. Then, the paper determined the identification scheme to impose some restrictions on the parameters of the SVAR model which conformed with the economic theory and the previous studies. Afterward, the paper performed some unit root tests and found all the variables in the SVAR model were integrated of order one, meaning the first difference forms of the variables must be used for the SVAR model. Finally, the paper estimated the SVAR model and employed the impulse-response analysis to measure the impacts of the monetary policy shocks on the variables in the VAR model. While estimating the SVAR model, the paper extended the model with the endogenously determined structural breaks using the Fourier approximation.

The empirical findings obtained from the extended SVAR analysis indicate that an increase in interest rates leads to an instantaneous decrease in consumer prices and the exchange rate. The findings also indicate that the final impact of the decrease in interest rates occurs in 10 months for consumer prices, whereas it appears in 9 months for the exchange rate. These results show that contractionary monetary policy decreases consumer prices and results in the appreciation of the TRY against foreign currencies. As for a shock in the exchange rate, the paper yields that a positive shock in the exchange rate, namely the depreciation of the TRY against

[6] To save space, the responses of the variables in the SVAR model to shocks to other variables are not presented in the paper. These results are available upon request.

currencies, increases interest rates. The paper also finds that consumer prices immediately increase as a result of an increase in the exchange rate and that the impact of the exchange rate on prices appears to be persistent as prices do not fall in time.

These findings provide considerable implications for the monetary policy of the CBRT. The first one is about the control horizon of the CBRT. The CBRT [15] defines the control horizon as the time elapsed between a change in interest rates and its observed ultimate impact on inflation. The control horizon of the CBRT is one year in its inflation reports. This paper finds that the ultimate impact of a change in interest rates on inflation occurs in 10 months. The findings of the paper, therefore, indicate that the impact of monetary policy on inflation occurs faster compared to the CBRT's estimations. Put differently, the monetary transmission lag in Turkey is shorter than the CBRT's estimations. For this reason, we argue that one of the reasons why the CBRT missed inflation targets may be the wrongly estimated control horizon by the CBRT. Hence, the findings of the present paper imply that the CBRT should shorten the control horizon, which in turn can increase the control of the CBRT over inflation and thus affect the effectiveness of monetary policy in Turkey. The second one is about the financial stability objective of the CBRT. The findings in the paper show that the impact of monetary policy in Turkey differs concerning financial assets. Accordingly, the monetary policy of the CBRT can affect the exchange rate, whereas it has no impact on the stock market index. The third one is related to the monetary policy reaction and loss functions of the CBRT. As the paper yields that an increase in the exchange rate results in an increase in interest rates, it can be argued that the CBRT has expanded these functions so that they can include the exchange rate. Put differently, the CBRT directly considers the exchange rate while implementing monetary policy. The last one is about ERPT to consumer prices in Turkey. The findings reveal that an increase in the exchange rate has positive and persistent effects on consumer prices. Some papers in the extant literature focus on the effect of a credible central bank on the degree of the ERPT process. Accordingly, Gagnon and Ihrig [31] find that the degree of ERPT considerably decreases if there is a credible central bank that implements contractionary monetary policy to reduce aggregate demand against an increase in the exchange rate. Besides, given the high correlation between the expected inflation rate and the actual inflation rate, Mishkin [46] reveals that an increase in the exchange rate will have a little impact on expected inflation and the inflation rate if the central bank's commitment to keeping inflation under control is strong. As this paper finds that an increase in the exchange rate has persistent impacts on prices, we contend the CBRT should more closely follow the exchange rate and more aggressively respond to an increase in the exchange rate.

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Declarations

Conflict of interest The author declares that there is no conflict of interest.

References

1. Akbaş, Y., Zeren, F., & Özekicioğlu, H. (2013). Money transmission mechanism in Turkey: Structural VAR analysis (in Turkish). *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi, 14*(2), 187–198.
2. Allegret, J. P., Couharde, C., & Guillaumin, C. (2012). The impact of external shocks in East Asia: Lessons from a structural VAR model with block exogeneity. *Economie Internationale, 132*(4), 35–89.
3. Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R., & Ragusa, G. (2019). Measuring Euro Area monetary policy. *Journal of Monetary Economics, 108*, 162–179.
4. Apergis, N., Bulut, U., Ucler, G., & Ozsahin, S. (2021). The causal linkage between inflation and inflation uncertainty under structural breaks: Evidence from Turkey. *The Manchester School, 89*(3), 259–275.
5. Banerjee, P., Arčabić, V., & Lee, H. (2017). Fourier ADL cointegration test to approximate smooth breaks with new evidence from crude oil market. *Economic Modelling, 67*, 114–124.
6. Barnett, W. A., Bhadury, S. S., & Ghosh, T. (2016). An SVAR approach to evaluation of monetary policy in India: Solution to the exchange rate puzzles in an open economy. *Open Economies Review, 27*(5), 871–893.
7. Becker, R., Enders, W., & Lee, J. (2006). A stationarity test in the presence of an unknown number of smooth breaks. *Journal of Time Series Analysis, 27*(3), 381–409.
8. Belke, A., & Polleit, T. (2009). *Monetary economics in globalised financial markets*. Springer.
9. Berument, H. (2007). Measuring monetary policy for a small open economy: Turkey. *Journal of Macroeconomics, 29*(2), 411–430.
10. Blinder, A. S. (1999). *Central banking in theory and practice*. The MIT Press.
11. Bofinger, P., Reischle, J., & Schachter, A. (2001). *Monetary policy: Goals, institutions, strategies, and instruments*. Oxford University Press.
12. Cambazoğlu, B., & Güneş, S. (2011). Monetary transmission mechanism in Turkey and Argentina. *International Journal of Economics and Finance Studies, 3*(2), 23–33.
13. Can, U., Bocuoglu, M. E., & Can, Z. G. (2020). How does the monetary transmission mechanism work? *Evidence from Turkey. Borsa Istanbul Review, 20*(4), 375–382.
14. Castro, V. (2011). Can central banks' monetary policy be described by a linear (augmented) Taylor rule or by a nonlinear rule? *Journal of Financial Stability, 7*(4), 228–246.
15. Central Bank of the Republic of Turkey (2022). Electronic data delivery system. Retrieved from https://evds2.tcmb.gov.tr/. Accessed 23 Apr 2022.
16. Clarida, R., Gali, J., & Gertler, M. (1998). Monetary policy rules in practice: Some international evidence. *European Economic Review, 42*(6), 1033–1067.
17. Clarida, R., Gali, J., & Gertler, M. (2000). Monetary policy rules and macroeconomic stability: Evidence and some theory. *The Quarterly Journal of Economics, 115*(1), 147–180.
18. Croux, C., & Reusens, P. (2013). Do stock prices contain predictive power for the future economic activity? A Granger causality analysis in the frequency domain. *Journal of Macroeconomics, 35*, 93–103.
19. Cushman, D. O., & Zha, T. (1997). Identifying monetary policy in a small open economy under flexible exchange rates. *Journal of Monetary Economics, 39*(3), 433–448.
20. Dağlaroğlu, T., Demirel, B., & Mahmud, S. F. (2018). Monetary policy implications of short-term capital flows in Turkey. *Empirica, 45*(4), 747–763.
21. Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366), 427–431.
22. Eichengreen, B., El-Erian, M., Fraga, A., Ito, T., Pisani-Ferry, J., Prasad, E., Rajan, R., Ramos, M., Reinhart, C., Rey, H., Rodrik, D., Rogoff, K., Shin H. S., Valesco, A., Mauro, B., and Yu, Y. (2011). Rethinking Central Banking. Retrieved from https://www.brookings.edu/research/rethinking-central-banking/. Accessed 1 Apr 2022.
23. Enders, W. (2015). *Applied econometric time series*. Wiley.
24. Erdem, E., Bulut, U., & Kocak, E. (2017). Have financial stability concerns changed the priority of the Central Bank of the Republic of Turkey? *Studies in Business and Economics, 12*(2), 35–45.
25. Erdoğan, S., & Yıldırım, D. Ç. (2009). Monetary transmission through interest rate channel in Turkey (in Turkish). *Eskişehir Osmangazi Üniversitesi İİBF Dergisi, 4*(2), 57–72.

26. Ertuğ, D., Özlü, P., & Yüncüler, C. (2018). How does the use of imported inputs affect exchange rate and import price pass-through? Retrieved from http://tcmbblog.org/wps/wcm/connect/blog/en/main+menu/analyses/how_does_the_use_of_imported_inputs_affect. Accessed 1 Apr 2022.
27. Federal Reserve Bank of St. Louis (2022). Industrial production: Total index. Retrieved from https://fred.stlouisfed.org/series/INDPRO. Accessed 10 Apr 2022.
28. Friedman, M. (1961). The lag in effect of monetary policy. *The Journal of Political Economy, 69*(5), 447–466.
29. Friedman, M. (1968). The role of monetary policy. *The American Economic Review, 58*(1), 1–17.
30. Friedman, M. (1972). Have monetary policies failed? *The American Economic Review, 62*(1/2), 11–18.
31. Gagnon, J. E., & Ihrig, J. (2004). Monetary policy and exchange rate pass-through. *International Journal of Finance & Economics, 9*(4), 315–338.
32. Gayaker, S., Ağaslan, E., Alkan, B., & Çiçek, S. (2021). The deterioration in credibility, destabilization of exchange rate and the rise in exchange rate pass-through in Turkey. *International Review of Economics & Finance, 76*, 571–587.
33. Ghosh, A. (2013). Exchange rate pass through, macro fundamentals and regime choice in Latin America. *Journal of Macroeconomics, 35*, 163–171.
34. Hajdukovic, I. (2022). Transmission mechanisms of conventional and unconventional monetary policies in open economies. *International Economics and Economic Policy*. https://doi.org/10.1007/s10368-021-00527-0
35. Iltas, Y., & Bulut, U. (2016). The relationships among the returns of investment instruments: A vector autoregressive approach for Turkey. *Theoretical & Applied Economics, 23*(4), 273–280.
36. Kara, H. (2016). A brief assessment of Turkey's macroprudential policy approach: 2011–2015. *Central Bank Review, 16*(3), 85–92.
37. Kılınç, M., & Tunç, C. (2014). Identification of monetary policy shocks in Turkey: a structural VAR approach. *CBRT Working Paper,* 1423.
38. Korhonen, I., & Wachtel, P. (2006). A note on exchange rate pass-through in CIS countries. *Research in International Business and Finance, 20*(2), 215–226.
39. Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics, 54*(1–3), 159–178.
40. Lange, R. H. (2013). Monetary policy reactions and the exchange rate: A regime-switching structural VAR for Canada. *International Review of Applied Economics, 27*(5), 612–632.
41. Lee, D. J., & Son, J. C. (2013). Nonlinearity and structural breaks in monetary policy rules with stock prices. *Economic Modelling, 31*, 1–11.
42. Lee, S., & Park, J. (2022). Identifying monetary policy shocks using economic forecasts in Korea. *Economic Modelling, 111*, 1–11.
43. Milas, C., & Naraidoo, R. (2012). Financial conditions and nonlinearities in the European Central Bank (ECB) reaction function: In-sample and out-of-sample assessment. *Computational Statistics & Data Analysis, 56*(1), 173–189.
44. Mishkin, F. S. (1995). Symposium on the monetary transmission mechanism. *Journal of Economic Perspectives, 9*(4), 3–10.
45. Mishkin, F. S. (1997). Strategies for controlling inflation. *NBER Working Paper,* 6122.
46. Mishkin, F. S. (2008). Exchange rate pass-through and monetary policy. *NBER Working Paper,* 13889.
47. Morozumi, A., Bleaney, M., & Mumuni, Z. (2020). Inflation targeting in low-income countries: Does IT work? *Review of Development Economics, 24*(4), 1529–1550.
48. Örnek, İ. (2009). Processing of monetary transmission mechanism channels in Turkey (in Turkish). *Maliye Dergisi, 156*(1), 104–125.
49. Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335–346.
50. Sims, C. A. (1980). Macroeconomics and reality. *Econometrica, 48*(1), 1–48.
51. Stone, M. M. R. (2003). Inflation targeting lite. *IMF Working Paper,* 03/12.
52. Svensson, L. E. O. (1997). Inflation forecast targeting: Implementing and monitoring inflation targets. *European Economic Review, 41*(6), 1111–1146.
53. Svensson, L. E. O. (1999). Inflation targeting as a monetary policy rule. *Journal of Monetary Economics, 43*(3), 607–654.

54. Taylor, J. (1993). Discretion versus policy rules in practice. Retrieved from https://web.stanford.edu/~johntayl/Onlinepaperscombinedbyyear/1993/Discretion_versus_Policy_Rules_in_Practice.pdf. Accessed 1 Apr 2022.
55. Tunc, C., & Kilinc, M. (2018). Exchange rate pass-through in a small open economy: A Structural VAR approach. *Bulletin of Economic Research, 70*(4), 410–422.
56. US Energy Information Administration (2022). Europe Brent spot price FOB. Retrieved from https://www.eia.gov/dnav/pet/hist/rbrteD.htm. Accessed 15 Apr 2022.
57. Varlik, S., & Berument, M. H. (2017). Multiple policy interest rates and economic performance in a multiple monetary-policy-tool environment. *International Review of Economics & Finance, 52*, 107–126.
58. Venter, Z. (2020). The interaction between conventional monetary policy and financial stability: Chile, Colombia, Japan, Portugal and the UK. *Comparative Economic Studies, 62*(3), 521–554.
59. Wu, J. C., & Xia, F. D. (2016). Measuring the macroeconomic impact of monetary policy at the zero lower bound. *Journal of Money, Credit and Banking, 48*(2–3), 253–291.
60. Yang, S. Y., & Doong, S. C. (2004). Price and volatility spillovers between stock prices and exchange rates: Empirical evidence from the G-7 countries. *International Journal of Business and Economics, 3*(2), 139–153.
61. Yilmaz, N., & Yucel, E. (2021). Exchange rate pass-through to consumer prices in Turkey: nonparametric kernel estimation evidence. Retrieved from https://mpra.ub.uni-muenchen.de/105895/. Accessed 23 Apr 2022.
62. Yıldırım, M. O. (2021). The channels of monetary policy transmission in Turkey: Evidence from structural VAR approach (in Turkish). *Ekonomik Yaklasim, 32*(120), 209–248.
63. World Bank (2022). World Bank open data. Retrieved from https://data.worldbank.org/. Accessed 1 May 2022.