# MONETARY POLICY SHOCKS AND EMPIRICAL ANOMALIES IN TURKEY

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## Abstract

This paper empirically investigates the effects of monetary policy shocks of a small open economy Turkey using a VAR approach. Orthogonal restrictions are formed based on the traditional closed economy VAR literature so that output and prices do not respond contemporaneously to monetary policy shocks. Additionally, simultaneous interaction between exchange rate and domestic interest rate is not allowed. A non-recursive structural identification scheme is also conducted for comparison and introduces two new assumptions: i) "simultaneity" between interest rates and real exchange rates ii) "information delays" that do not allow the monetary policy to react to output changes instantaneously. Both identification specifications are extended in different ways to check the robustness of the results. The orthogonalized and structural impulse-responses indicate that qualitative inferences about the effects of monetary policy in Turkey are not different across identification methods; a recursive identification scheme or a non-recursive one, and both present exchange rate and price puzzles.

**Keywords:** Exchange rate puzzle, monetary policy, price puzzle, VAR

**JEL Classification:** C32, E52, F41

# TÜRKİYE'DEKİ PARA POLİTİKASI ŞOKLARI VE AMPİRİK ANOMALİLER

## Özet

Bu çalışma para politikası şoklarının Türkiye ekonomisi üzerindeki etkilerini VAR yaklaşımı ile analiz etmektedir. Çalışmada kullanılan ortogonal kısıtlamalar, geleneksel kapalı ekonomi VAR literatürüne dayanarak oluşturulmuş olup, çıktı ve fiyat düzeyi para politikası şoklarına eş zamanlı olarak cevap vermemektedir. Ek olarak, döviz kurları ve ulusal faiz oranları arasında karşılıklı etkileşime de izin verilmemektedir. Karşılaştırma yapabilmek amacıyla yinelemeli olmayan yapısal kısıtlamalarda çalışmada kullanılmış olup iki yeni varsayım ortaya koyulmuştur. Bunlardan ilki döviz kuru ve faizler arasında eşzamanlılık olduğunu öne sürmektedir. İkincisi ise para politikasının çıktı değişmelerine karşı eş zamanlı olarak tepki veremediğini ifade eden "bilgi gecikmeleri" varsayımıdır. Her iki kısıtlama yapısında da sonuçların tutarlılığını kontrol etmek için farklı analizler yapılmıştır. Ortogonal ve yapısal etki-tepki analizleri, uygulanan para politikalarının etkilerinin, ortogonal ve yapısal kısıtlama yöntemlerine göre farklılık göstermediğini ifade etmekte ve Türkiye'de hem fiyat hem de döviz kuru bulmacalarına rastlandığını ortaya koymaktadır.

**Anahtar Kelimeler:** Döviz kuru bulmacası, para politikası, fiyat bulmacası, VAR.

**JEL Sınıflaması:** C32, E52, F41

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## 1. Introduction

The effects of exogenous monetary policy shocks on macroeconomic variables have been subjected to great deal of attention by scholars, policymakers and governors. Proper identification of monetary policy shocks is crucial for a central bank to understand the transmission mechanism of monetary policy. However, exposing the link between monetary policy and its impacts on macroeconomic variables is not always straightforward as the vast empirical literature often found puzzling results named as the "liquidity puzzle", "price puzzle", "exchange rate puzzle", and "forward discount bias puzzle (delayed overshooting)".[2]

Liquidity puzzle represents the empirical anomaly that positive innovations in monetary aggregates lead to an increase in interest rate rather than a decrease. Considering the liquidity puzzle, Sims (1992) proposed using short-term interest rate instead of monetary aggregates since innovations in monetary aggregates may not ideally characterizes changes in monetary policy if money demand shock occurs. Sims' suggestion was not found satisfactory since it yielded another empirical anomaly, price puzzle. Price puzzle, on the other hand, refers that contractionary monetary policy is associated with a rise in prices rather than a decline. Price puzzle may occur by a cost channel of the interest rate where the elevated domestic interest rate raises borrowing costs of firms and prices (Sims, 1992). According to Sims, price puzzle may disappear if commodity prices were included in the VAR model. He simply claims that failure to include a variable that signals future inflation may constitute a misspecified VAR model. On the other hand, some authors insist on using monetary aggregates when analyzing the monetary policy decisions since monetary aggregates provide crucial information to identify proper monetary policy shocks that is not contained in the domestic interest rates. For example, Barnett, Bhadury and Ghosh (2016) suggested using of monetary aggregates as their models with monetary aggregates perform better than those without money. Also Eichenbaum and Evans (1995), Kim and Roubini (2000), Peersman and Smets (2001), Kim and Lim (2018) have identified their models with monetary measures.[3]

Dornbusch's (1976) overshooting hyphothesis, which is one of the core foundations of the international economics, refers that positive innovations in domestic interest rate lead to an impact appreciation of home currency (overshooting) before depreciating back to the

[2] For more detailed information of the empirical anomalies, see Sims (1992) and Kim and Roubini (2000).

[3] In literature, sign restrictions on impulse responses, as explained in Uhlig (2005), are also employed to eliminate liquidity and price puzzles and identify proper monetary policy shocks (see Faust and Rogers, 2003; Scholl and Uhlig, 2008; Bouakez and Normandin, 2010; Kim and Lim, 2018)

uncovered interest parity (UIP). However, empirical studies are largely remained cautious to support Dornbusch's overshooting hyphothesis. In literature, a large body of literature has found support for "exchange rate puzzle" and "forward discount bias puzzle". The term "exchange rate puzzle" is used to explain the empirical anomaly that exchange rate moves in the wrong direction with respect to a monetary policy shock, i.e contractionary monetary policy leads to impact depreciation of home currency. Grilli and Roubini (1995) identified monetary policy changes with innovations in short-term interest rates to deal with liquidity puzzle and found that contractionary policy shocks on US domestic short-term interest rates result in exchange rate puzzle. According to Sims (1992), the cost channel of positive innovations in interest rates which generates inflationary pressures on domestic prices may also explain the exchange rate puzzle as inflationary shocks lead to depreciation in home currency. Finally, if a contractionary monetary policy shock exhibits persistent appreciation of home currency for the periods up to 2-3 years, this phenomenon is named as "delayed overshooting". Eichenbaum and Evans (1995) documented that a contractionary monetary policy in the US causes persistent and significant appreciations in nominal and real exchange rates and significant, persistent deviations from the UIP condition. Scholl and Uhlig (2008), Bouakez and Normandin (2010), and Heinlein and Krolzig (2012) found supportive findings for a substantial delay in overshooting and significant deviations from the UIP while Kim and Roubini (2000), Bjørnland (2009), and Kim and Lim (2018) revealed that the exchange rate appreciates significantly with only a small delay in overshooting. In addition, Bjørnland criticized the past studies which provide evidences for the presence of the delayed overshooting in the sense that these studies have largely ignored the strong simultaneous interaction between monetary policy and exchange rate movements. In contrast, she allowed simultaneity between interest rate and exchange rate in a study of four open small economies and showed that the puzzles disappear.

The most common approach for analyzing the effects of monetary policy in the past studies has been the vector autoregressive (VAR) approach. The major challenge when analyzing the impacts of monetary policy shocks through a VAR model is to decide how to identify VAR innovations properly based on the economic theory. Traditionally, domestic (or real sector) variables "output" and "prices" are placed above the financial variables "exchange rate" and "interest rate" in the ordering when applying standard recursive zero restrictions on the impact matrix of shocks. This simply refers that the domestic variables are affected by financial variables with a lag while the financial variables are influenced by the domestic variables contemporaneously. This set-up also characterizes the sluggish reaction of real sector to a shock in financial sector and constitutes a causal contemporaneous chain from top to bottom. However, designing the true interaction between monetary policy and exchange rate is a contentious issue. Sims (1992), Eichenbaum and Evans (1995), Kim and Roubini (2000), and Peersman and Smets (2001) claim that exchange rate is contemporaneously affected by monetary policy shocks while some others swap the places of financial variables in the ordering and restrict exchange rate from responding simultaneously to a monetary policy shock (see Favero and Marcellino, 2004; Mojon and Peersman, 2003). Unfortunately, recursive structure of the identification restrictions is often found dubious. Grilli and Roubini (1996) emphasized that "the world is likely to be much less recursive than what is assumed in this identification scheme" (p.856). Cushman and Zha (1997) stated that the price puzzle may disappear if structure of the VAR innovations is not identified by using standard recursive contemporaneous restrictions. According to Bjørnland (2009), the possible existence of a strong contemporaneous interaction between the financial variables requires non-recursive set of identification restrictions.

Besides the international debate, there are also some studies that focus on Turkey. Berument (2007) analyzed the effects of monetary policy shocks over the highly inflationary period of 1986 and 2000 using the "spread" between the Central Bank's interbank interest rate and the depreciation rate of home currency as an indicator of the stance of the CBRT's monetary policy. The argument is that the monetary policy was managed during the most of the sample period either by influencing interbank interest rates or by setting the exchange rate. His results obtained from the recursive identification structure showed that contractionary monetary policy is associated with a decrease in price level and output while it produces impact appreciation of home currency (no puzzles).[4] Kilinc and Tunc (2014) followed a more generalized structural approach based on the block exogeneity assumption from Cushman and Zha (1997) for a more recent period 2006-2013 using overnight interest rates to identify monetary policy shocks. Their results were free of the exchange rate and price puzzles in line with Berument (2007). However, they further showed that the use of Cholesky identification exhibits price puzzle in Turkish economy. Similarly, Civcir and Caglayan (2010) analyzed the effect of interest rate on exchange rate covering two different analysis periods, 1987-2001 and 2002-2009. They performed the recursive Cholesky decomposition and used overnight interest rate as a proxy for the money market short-term interest rate. Their empirical results revealed that the interest rate increases are associated with a depreciation of the currency (exchange rate puzzle). The authors also claimed that their results are robust to the ordering of the variables since residual correlations are quite low. Ulke and Berument (2016) documented the asymmetric effects of monetary policy shocks on the exchange rate, output and inflation. They employed a nonlinear vector auto-

[4] See also Berument and Dincer (2008) for similar results.

regressive model using monthly data between 1990 and 2014. Their empirical results indicated that innovations in overnight interest rates direct output, prices and exchange rates as economic theory suggests. However, the impacts of expansionary monetary policy shocks were found to be weaker than the impacts of contractionary monetary policy shocks. Additionally, the more the size of a shock increases, the more the difference between the impacts of contractionary and expansionary monetary policies also raises. Finally, Onder and Villamizar-Villegas (2018) studied the effects of monetary policies and their impacts on economic activity during the period of 2002-2010. They concluded that changes in the policy rate affected inflation and output growth, with a lag delay of four and two quarters, respectively.

This paper basically analyzes the impacts of monetary policy shocks on various macroeconomic variables and emerging empirical puzzles which were commonly documented by a large body of international literature in the case of a small open market economy, Turkey using a VAR approach. The VAR model is estimated considering the monthly sample period between 2011:M1 and 2018:M12 during which the Central Bank of the Republic of Turkey (CBRT) has introduced a new monetary policy framework. While the primary objective of the Central Bank was to achieve and maintain price stability, the devastating impacts of global financial crisis in 2008-2009 revealed that ignoring the financial stability may easily threaten price stability. The crisis conditions led the CBRT to seek alternative policies. As a result, the CBRT has designed a new monetary policy framework since the end of 2010 which aims to ensure financial stability without compromising price stability. Through the new framework, the bank has started to use more than one interest rate indicators (BIST interbank overnight repo rate, policy rate, overnight lending/borrowing rates etc.). Since the new monetary policy framework was based on a combination of policy instruments, this paper employs the weighted average funding cost (WAFC) to represent the monetary policy stance of the CBRT. The WAFC simply refers the weighted average of the interest rates of funding made by the Central Bank with various instruments (repo etc.) in different maturities (overnight, weekly, etc.) in order to meet the liquidity needs of the market.

Throughout the paper, two different identification schemes are performed for comparison. I first perform recursive Cholesky Decomposition of variance covariance matrix of VAR innovations. Considering the price puzzle, the unrestricted VAR approach is conducted with a measure of future inflation in line with Sims (1992) and some others (see Grilli and Roubini, 1995, Kim and Roubini, 2000; and Peersman and Smets, 2001). The orthogonalized impulse-responses show that recursive restrictions by incorporating small open economy features exhibit the well-known price and exchange rate puzzles. In addition, robustness checks of Cholesky identification scheme confirm the stability of the puzzling results. This paper also performs an open economy structural VAR (SVAR) model to deal with empirical anomalies encountered in Cholesky set-up. The structural identification scheme introduces two new assumptions. First assumption is proposed by Sim and Zha (2006) and Kim and Roubini (2000) and presents the "information delays" that do not allow the monetary policy reaction function to respond within the month to output changes. Second assumption allows for simultaneous interaction between monetary policy and exchange rate in line with Bjørnland (2009).

This paper differs from the past studies that center on Turkey in its analysis period, selected indicator that represents the monetary policy stance of the CBRT and empirical results. First, using the similar policy indicators in line with the past studies such as overnight interest rate or interbank rates etc. cannot truly represent the monetary policy stance of the CBRT as the bank has used more than one interest rate through the new monetary policy framework since the end of 2010. Hence, the WAFC emerges as a better measure to reflect the monetary policy stance of the CBRT. Second, the empirical findings obtained from the past international or local studies roughly conclude that the Cholesky specification of the innovations tends to generate more puzzling results while structural identification appears to be more succesful in solving puzzles. However, to the best of my knowledge, this is the first empirical paper documenting the presence of "exchange rate and price puzzles" in the case of Turkey using different identification schemes; a recursive identification or a non-recursive one. This result is striking since it reveals the fact that monetary transmission mechanism does not work as intended by the bank. The reason why such puzzling outcomes are observed as a response to monetary policy shock is likely to be related to lack of "monetary policy credibility". Since the CBRT consistently misses the target inflation rates during the 2000's, agents' future expectations do not apparently coincide with the official commitments of the bank.

The structure of this paper is as follows. Section 2 summarizes the VAR methodology and presents details for the identification structures used throughout the paper. Section 3 introduces the identification restrictions based on the economic theory and reports the empirical results along with several robustness checks. Finally, Section 4 concludes.

# 2. Methodology

## 2.1. A VAR Model for Turkey

This paper performs an unrestricted VAR model to explore the effects of an exogenous monetary policy shock. A $p^{th}$ order unrestricted VAR model with exogenous variables has the following form:

$$Y_t = v + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \theta X_t + u_t, \qquad (1)$$

where $Y_t$ is defined as the nx1 vector of the endogenous variables; $X_t$ is a nx1 vector of exogenous variables; v is a vector of fixed parameters, $A_i$ is nxn matrices of parameters. $u_t \sim N(0, \Sigma)$ is a nx1 vector of innovations that are assumed to be uncorrelated with their own past values and uncorrelated with all of the right hand-side variables. However, they may be contemporaneously correlated with each other, that is, the positive definite variance-covariance matrix of innovations Σ is nondiagonal. This is a common issue in a VAR analysis, and it requires to use some identifying assumptions to have interpretable causal impulse-responses as discussed in the next section.

Throughout the paper, the vector of endogeous variables includes industrial production index (PROD), consumer prices (CPI), the domestic interest rate (weighted average funding cost of the CBRT) (IR), and real effective exchange rate (REER). An increase in REER indicates an appreciation of the home currency against a broad basket of currencies. The vector of exogenous variables (or foreign variables) contains world commodity price index (WCPI), US Federal Funds rates (FED), and US industrial production index (USPROD). To reflect the structure of the small open economy, foreign variables are treated as exogenous factors. Foreign interest rate FED is included into the VAR (1) model to control for the effects of US monetary policy. Bjørnland (2009) treats foreign interest rate as an endogenous variable and places the foreign interest rate first in the ordering. Basically, this implies that the remaining endogenous variables output, prices, domestic interest rate and real effective exchange rate are contemporaneously affected by foreign interest rates. However, this specification does not impose any restriction on the the lagged impacts of the remaining endogenous variables on foreign interest rate. Turkey is a small economy and endogenous variables are expected to have no effect on FED. Consequently, the exogenous use of foreign interest rate in the small open economy enables us to avoid misidentification of the VAR model (1). The second exogenous variable WCPI is included into the VAR model (1) for two reasons. First, inclusion of WCPI helps to control for inflationary supply shocks since commodity prices influence significantly the evolution of inflation in a small open economy such as Turkey. Policy makers are expected to watch commodity prices carefully and react to any severe changes for eliminating inflationary pressures. Second, as pointed out by Sims (1992), price puzzle may appear when monetary policy has not been correctly identified due to a failure of including a variable that signals future inflation. Hence, world commodity prices are involved for reflecting future inflation. Finally, USPROD is included to control for the change in world demand conditions.[5] The foreign variables have contemporaneous impact on the endogenous variables while there is no feedback from the endogenous variables to the foreign variables.

The choice of variables is consistent with literature (see Eichenbaum and Evans, 1995; Grilli and Roubini, 1995; Kim and Roubini, 2000; Scholl and Uhlig, 2008; Peersman and Smets, 2001; Kim and Lim, 2018). All series, except domestic interest rate and the Federal Funds rate, are seasonally adjusted and expressed in logarithm (see Appendix/Table A1 for the description of data and sources). The VAR model is estimated using first-differenced stationary data since all variables are integrated of order one.[6,7] Hence, the vector of endogenous variables can be written as:

$$Y_t = (\Delta PROD_t \;\; \Delta CPI_t \;\; \Delta IR_t \;\; \Delta REER_t)^T \tag{2}$$

The optimum number of lags in the VAR model is selected by Hannan Quinn Information Criterion (HQIC). The max lag length is set to twelve. No lags are assumed for exogenous variables in the analysis to save the degree of freedom. Exogenous deterministic components of the VAR model (constant and trend) are also selected by HQIC. The appropriate VAR model necessitates the stability of the system. If the VAR is stable, the impulse-responses decay over time since structural shocks have temporary impacts on the series. As shown by Hamilton (1994), stability of the VAR requires the modulus of the each eigenvalue is strictly less than one.

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5 See Peersman and Smets (2001), Kim and Roubini (2000), Bjørnland (2009), Kim and Lim (2018) for similar set of exogenous factors.

6 Phillips-Perron (1988) unit root test results are presented in Appendix/Table A2. Since the first difference of the logarithm of a variable is approximately equal to its percentage change, the first differences of logged variables can be considered as percentage change in the variables, that is, growth rates of the original variables.

7 This paper does not follow Johansen's framework (1988, 1991) including cointegration and maximum-likelihood estimation of appropriate error correction representation of the VAR model since the leading studies of the related literature ignore the cointegration relation among the original variables. See Cushman and Zha (1997), Kim and Roubini (2000), Peersman and Smets (2001), Bjørnland (2009), Kim and Lim (2018), Barnett, Bhadury and Ghosh (2016), Grilli and Roubini (1995,1996), Bouakez and Normandin (2010).

## 2.2. Identification of the VAR Innovations

The innovations $u_t$ can be assumed to be a linear transformation of mutually uncorrelated structural shocks $\varepsilon_t$ such that:

$$u_t = P\varepsilon_t \text{ where } E(u_t u_t^T) = \Sigma = PP^T \quad (3)$$

Equation (1) can be written as the following form:

$$A(Y_t - v - A_1 Y_{t-1} - A_2 Y_{t-2} - \cdots - A_p Y_{t-p}) = Au_t = B\varepsilon_t \text{ where } P = A^{-1}B \quad (4)$$

where A and B are nonsingular nxn matrices of parameters to be estimated.[8] From 3, it can be written that

$$E(u_t u_t^T) = \Sigma = PP^T = A^{-1}B(A^{-1}B)^T \quad (5)$$

$A_i$ and $\Sigma$ can be econometrically identified without any further identification assumptions by using simple regressions. However, all elements in matrix P are required to be identified to have an interpretable causal impulse-response function. In a n-variable VAR, symmetric variance-covariance matrix $\Sigma$ has $(n^2+n)/2$ independent elements while P has $n^2$ unknowns. Hence, $(n^2-n)/2$ additional assumptions are needed to recover all elements of P. Without these identification assumptions, the mutually uncorrelated shocks $\varepsilon$ from the VAR innovations cannot be uniquely separated. There are several ways to choose such a matrix P. Sims (1980) proposed Cholesky Decomposition of $\Sigma$ to choose such a P. The unique lower triangular matrix P is called Cholesky factor of $\Sigma$ . Cholesky restrictions require that A is a lower triangular matrix with ones on the diagonal and B is a diagonal matrix. This process produces identity variance covariance matrix of $\varepsilon_t$ since

$$E(\varepsilon_t \varepsilon_t^T) = E(P^{-1}u(P^{-1}u)^T) = E(B^{-1}Au(B^{-1}Au)^T) = B^{-1}AE(uu^T)(B^{-1}A)^T$$
$$= B^{-1}A\Sigma(B^{-1}A)^T = I_n \quad (6)$$

Now, variance covariance matrix of uncorrelated structural shocks $\varepsilon$ are diagonal, and each orthogonalized shock has unit variance, that is $\varepsilon_t \sim N(0, I_n)$ and $E(\varepsilon_t \varepsilon_s^T) = 0_n$ for $t \neq s$ Then, one can investigate the impacts of structural shocks over time to a particular innovation in $u_t$. This whole scheme is known as “orthogonalization” and produces orthogonalized impulse-response functions (OIRF). Since orthogonal shocks are uniquely identified using Cholesky factor P based on the lower triangular identifying assumptions, the first variable in the order

[8] Exogenous variables are excluded for simplicity.

is contemporaneously unaffected by all other variables. That is, the variables are ordered from most to least exogenous. This approach imposes recursive identification structure and causation, that is a Wold-causal chain. The contemporaneous causal chain from top to bottom might subject to criticism unless there exists a strong economic rationale behind the Cholesky order (2). On the other hand, more generalized structural VAR method is also performed simply placing non-recursive zero restrictions. Imposed constraints in SVAR models are typically motivated by economic theory and allow desired causal relationships among variables. In the SVAR approach, P can be any structure as long as it has enough restrictions consistent with economic theory.

## 3. Empirical Results

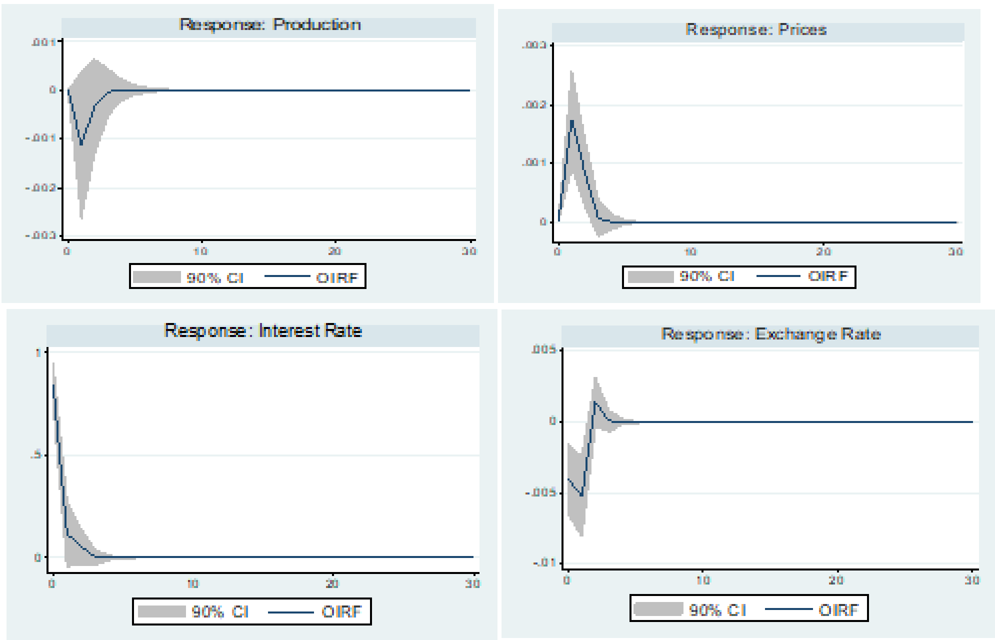
### 3.1. Cholesky Decomposition

This section identifies the exogenous monetary policy shocks through a standard recursive Cholesky Decomposition along with the variables ordered as in (2). Considering the liquidity puzzle, domestic interest rate is used to identify monetary policy shocks rather than involving monetary aggregates consistent with Sims (1992) and Grilli and Roubini (1995). This choice appears to be reasonable as interest rate has been a primary measure of monetary policy stance of the CBRT during the analysis period.

As shown in the endogenous vector (2), the domestic variables are placed above the financial variables as standard in the literature. This reflects the sluggish reaction of real sector to shocks in financial variables. The interest rate equation is assumed to be the reaction function of the monetary authority and placed under the domestic variables output and prices in the ordering following the traditional closed economy VAR literature. The closed economy VAR literature simply states that monetary policy shock affects domestic variables with a lag while domestic shocks drive monetary policy instantenously. This assumption is consistent with the transition mechanism of monetary policy suggested by Christiano, Eichenbaum and Evans (1999, 2005), Grilli and Roubini (1996), Kim and Roubini (2000), Peersman and Smets (2001), Bjørnland (2009). The major challenge in this recursive set-up is to determine the proper interaction between monetary policy and exchange rate. First, the exchange rate is ordered last in the ordering. This implies that interest rate is restricted from responding instantaneously to the exchange rate shock while the exchange rate does respond to contemporaneous changes in the interest rate in line with Sims (1992), Eichenbaum and Evans (1995), Kim and Roubini (2000), and Peersman and Smets (2001). Additionally, exogenous policy shocks have no contemporaneous impact on output and prices but may affect the exchange rate simultaneously. Exchange rate, being an asset price, reacts contemporaneously to all remaining structural shocks. The order of the variables also refers that output and prices slowly react to the exogenous real exchange rate shocks over time due to the "pass through" process of exchange rates.[9] Later, I also switch the places of exchange rate and domestic interest rates in the ordering and restrict the exchange rate from responding contemporaneously to a monetary policy shock. The following equations summarize the baseline Cholesky identification scheme:

$$\begin{pmatrix} A_{11} & 0 & 0 & 0 \\ A_{21} & A_{22} & 0 & 0 \\ A_{31} & A_{32} & A_{33} & 0 \\ A_{41} & A_{42} & A_{43} & A_{44} \end{pmatrix} \begin{pmatrix} u_{PROD_t} \\ u_{CPI_t} \\ u_{IR_t} \\ u_{REER_t} \end{pmatrix} = \begin{pmatrix} \varepsilon_{PROD_t} \\ \varepsilon_{CPI_t} \\ \varepsilon_{IR_t} \\ \varepsilon_{REER_t} \end{pmatrix} \quad (7)$$

**Figure 1:** Baseline Cholesky Specification, Impulse Responses to Exogenous Monetary Policy Shocks




**Notes:** Figure 1 reports the orthogonalized impulse-responses of the endogenus variables to a one standard deviation exogenous monetary policy shock and 90 percent confidence intervals (grey area). The VAR model is estimated with a lag and constant. Since the modulus of each eigenvalue is strictly less than one, the selected VAR model satisfies the stability condition (see Appendix/ Table A3).

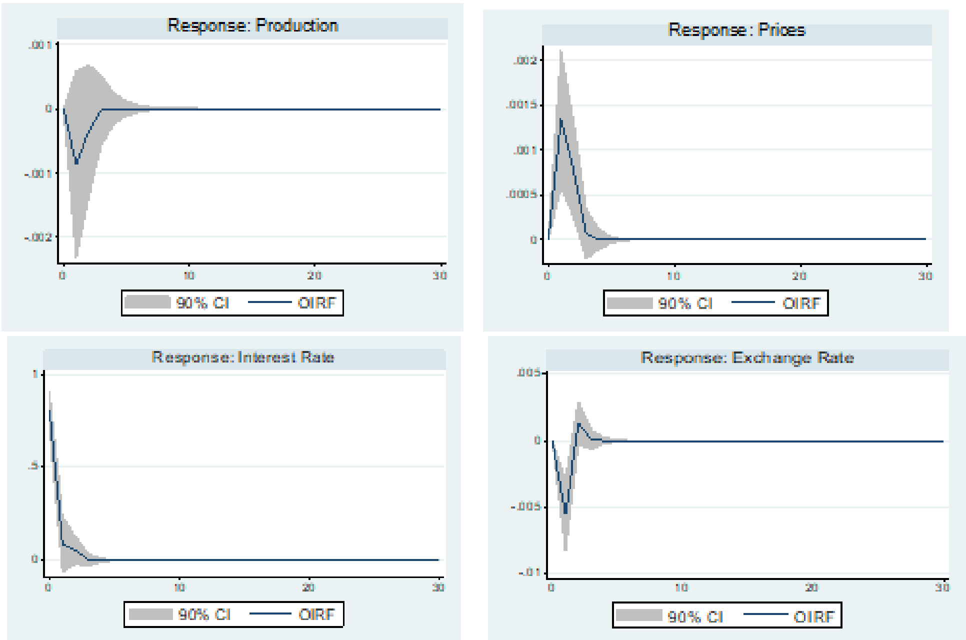
[9] Placing the exchange rate below the domestic variables is quite reasonable since industrial production is expected to react with a lag to changes in financial environment as a result of high adjustment costs to production in line with the literature (Berument, 2007 and Kilinc and Tunc, 2014 for an emerging country Turkey; Barnett, Bhadury and Ghosh, 2016 for an emerging country India; Bjornland, 2009 and Kim and Lim, 2018 for small open economies; Peersman and Smets, 2001 for Euro Area; Kim and Roubini, 2000 for industrialized countries). Additionally, there is a large body of the empirical literature which confirm the delayed impact of real exchange rate shock on domestic price responses in Turkey (see Kara and Ogunc, 2005; Arbatli, 2003; Volkan, Saatcioglu and Korap, 2007; Ogunc, Ozmen and Sarikaya, 2018). For a more detailed literature survey on pass-through process in Turkey, please see Dedeoglu and Kaya (2015, p. 93).

Figure 1 graphs the orthogonalized impulse-responses of the endogenous variables to a one standard deviation exogenous monetary policy shock. In Figure 1, the monetary policy shock raises interest rate instantaneously (i.e. a contractionary monetary policy), and the contemporaneous impact (t=0) is statistically significant. An unexpected rise in the domestic interest rate tends to be followed by an immediate and statistically significant real depreciation of the exchange rate. The maximum impact of the policy shock on the exchange rate occurs in one month. Following the immediate depreciation impact in response to a contractionary monetary policy shock (exchange rate puzzle), the impact thereafter quickly dies out.

Positive innovations in the monetary policy generates a fall in output in the very short-run consistent with general indication of tighter monetary policy stance; an increase in interest rate elevates the cost of capital and decreases purchase of durable goods and firm investments (interest rate channel). However, the impact is always statistically insignificant. Finally, the prices significantly increase in response to a tightening shock in domestic interest rates. Domestic prices react quickly and move in unexpected direction (price puzzle) before returning to baseline. The reason more likely is that elevated interest rate quickly raises prices by its cost channel. Consequently, the baseline Cholesky specification does generate puzzling results. Finally, using additional exogenous factor “world commodity prices” for involving future inflation does not appear to be successful in solving the price puzzle.[10]

Now, the baseline specification is reordered. I introduce second set of recursive identification restrictions considering a possible misidentification problem. Basically, an alternative Cholesky order is formed by swapping the places of exchange rates and domestic interest rates in (2). Based on the new order, exchange rate is restricted from responding instantaneously to the exogenous monetary policy shock while the interest rate does respond to contemporaneous changes in the effective exchange rate in line with Favero and Marcellino (2004) and Mojon and Peersman (2003). Figure 2 displays the orthogonalized impulse-responses of the endogenous variables with respect to an unexpected exogenous monetary policy shock. The monetary policy shock again immediately raises interest rate in line with the baseline order. As seen in Figure 2, the reactions of the remaining endogenous variables to a monetary policy shock in the alternative order are also quite consistent with what was found in Figure 1. The results are not sensitive to the reordering the financial variables since the covariance between financial variables may be close to zero. However, the covariance may also be close to zero as the impact of the real exchange rate shock on the monetary policy cancels out the impact of the policy shock on the real exchange rate if they carry opposite signs. Therefore, allowing for contemporaneous interaction between financial variables and considering non-recursive structure of identification restrictions may recover true exogenous policy shocks. “Simultaneous interdependency” between financial variables will be discussed later in Section 3.2.

**Figure 2:** Alternative Cholesky Specification, Impulse Responses to Exogenous Monetary Policy Shocks




**Note:** Figure 2 reports the orthogonalized impulse-responses of the endogenous variables ordered as in $Y_t = (\Delta PROD_t \quad \Delta CPI_t \quad \Delta REER_t, \Delta IR_t)^T$ to a one standard deviation exogenous monetary policy shock and 90 percent confidence intervals (grey area).

### 3.1.1. Robustness of Baseline Cholesky Idenfication

VAR models have often been criticized for not being robust to the alternative subsamples of the data and Cholesky orderings. This section provides robustness checks of the baseline Cholesky identification in (7).

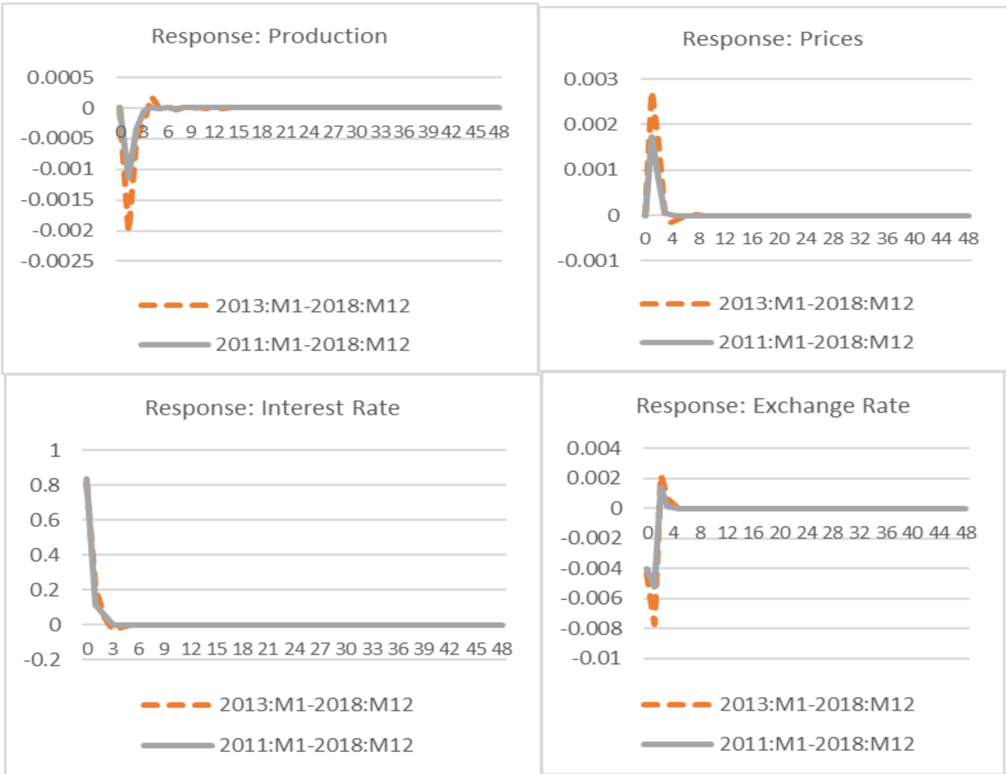
***Stability of Impulse Responses: Alternative Subsample***

As one might statistically wonder whether the results are sensitive with respect to randomly selected subsamples, this section performs the robustness analysis of the baseline Cholesky identification based on the alternative starting point. Since the inclusion of additional

[10] Since the trade linkage is much stronger between Turkey and Euro Area, the results are also controlled by using Euro Area foreign variables; Euro Area production index (EAPROD) and interest rates (EAIR). As shown in Appendix/Figure A1, the results does not change.

starting points for the further years largely reduces the sample size, the impulse-responses are reproduced only for the alternative subsample, 2013:M1-2018:M12.[11] The baseline sample period, on the other hand, refers the whole sample. Figure 3 shows the impulse-responses of the each endogenous variable in response to an exogenous monetary policy shock considering the new subsample and baseline period, 2011:M1-2018:M12. As displayed in Figure 3, even though there exists some quantitative differences between baseline and alternative subsample, alternative subsample exhibits qualitatively consistent results with the one obtained from the baseline.

**Figure 3:** Robustness of the Baseline Cholesky Specification: Alternative Subsample




**Notes:** Figure 3 reports the orthogonalized impulse-responses of the endogenous variables to a one standart deviation exogenous monetary policy shock over the baseline and alternative sample periods. Alternative subsample VAR model also satisfies the stability condition and includes a lag and constant.

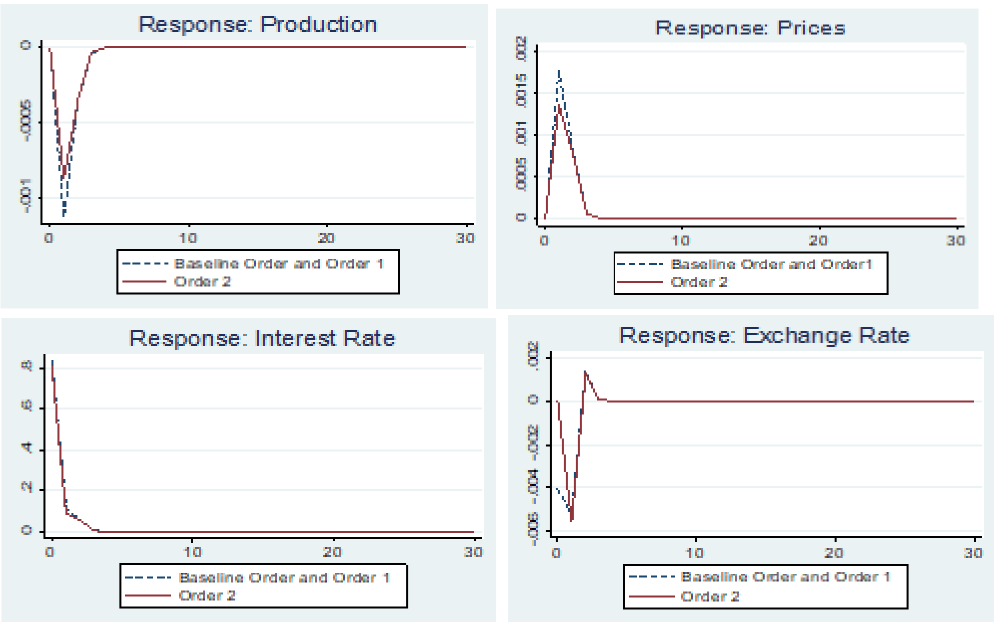
[11] However, the impulse-responses for the additional starting point, 2015:M1 are also available upon request, and the reactions of the variables qualitatively remain same.

### *Stability of Impulse Responses: Different Cholesky Orders*

This section changes the order of the variables in line with the the identification assumptions outlined in Section 3.1. That is, the domestic variables are still placed above the financial variables to reflect the lagged reaction of real sector to shocks in financial variables. Therefore, one can also form the following two alternative Cholesky orders by switching the position of domestic and foreign variables:[12]

Order 1 = $(\Delta CPI\ \Delta PROD\ \Delta IR\ \Delta REER)^T$ and Order 2 = $(\Delta CPI\ \Delta PROD\ \Delta REER\ \Delta IR)^T$.

**Figure 4**: Robustness of the Baseline Cholesky Specification: Alternative Orders



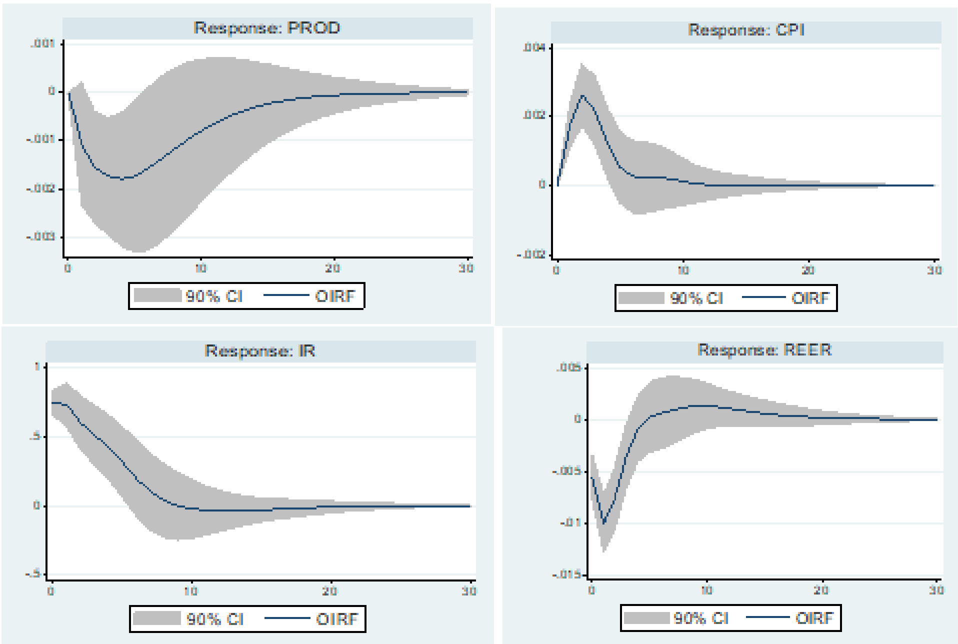

**Notes:** Figure 4 reports the orthogonalized impulse-responses of the endogenous variables to a one standart deviation exogenous monetary policy shock. Order 1 and 2 represent the following endogenous vectors: Y=$(\Delta CPI\ \Delta PROD\ \Delta IR\ \Delta REER)^T$ and Y=$(\Delta CPI\ \Delta PROD\ \Delta REER\ \Delta IR)^T$, respectively.

The baseline and alternative impulse-responses reported in Figure 4 provide evidences that the reaction of the variables are robust to the alternative ordering of the variables.

[12] The baseline Y = $(\Delta PROD_t\ \ \Delta CPI_t\ \ \Delta IR_t\ \Delta REER_{t,})^T$ and alternative order Y= $(\Delta PROD\ \ \Delta CPI\ \ \Delta REER\ \ \Delta IR)^T$ have already analyzed in the preceding section.

Before finishing this section, it is worth taking a closer look at the choice of the data transformation used in this paper. As expressed in Section 2.1, the choice of data is consistent with the literature. However, a large body of literature estimated their VAR models in levels rather than first differences (see Eichenbaum and Evans, 1995; Grilli and Roubini 1995; Kim and Roubini, 2000; Peersman and Smets, 2001; Scholl and Uhlig, 2008; Barnett, Bhadury and Ghosh, 2016; and Kim and Lim, 2018). Now, the results are reproduced using all the variables in their levels in line with the existing literature for comparison. Figure 5 reports the reactions of the variables in response to a monetary policy shock obtained from running the VAR model (1) in levels. Even though the variables tend to move more gradually in comparison with the VAR model in first differences, the VAR model in level also generates same puzzling outcomes. Overall, the results in Figures 3, 4 and 5 confirm the stability of the baseline Cholesky identification (7). The next section introduces a structural VAR analysis and identifies monetary policy shocks without restricting the contemporaneous responses of financial variables.

**Figure 5:** Baseline Cholesky Specification with the Variables in Levels, Impulse Responses to Exogenous Monetary Policy Shocks




**Notes:** Figure 5 reports the orthogonalized impulse-responses of the endogenus variables as in $Y_t = (PROD_t \quad CPI_t \quad IR_t \; REER_t)^T$ to a one standart deviation exogenous monetary policy shock and 90 percent confidence intervals (grey area). The VAR model is estimated with two lags, a linear trend and constant. Since the modulus of each eigenvalue is strictly less than one, the VAR model satisfies the stability condition.

### 3.2. Structural Identification Scheme

The recursive VAR practice which has been discussed in the preceding section has revealed puzzling results (exchange rate and price puzzles). This section, on the other hand, differs from the more traditional VARs due to allowing for contemporaneous interaction between the interest rate and the exchange rate. The following assumptions are made for the structural identification:

i. Recursive identification scheme imposing contemporaneous causal chain from top to bottom and their validities are subject to criticism unless there exists a strong economic rationale behind the selected Cholesky order. Faust and Rogers (2003) indicated that open economy VAR models should analyze monetary policy shocks without restricting the contemporaneous response of financial variables. Similarly, as stated by Bjørnland (2009), if there exists a simultaneous interaction between the financial variables and one disregards the simultaneity, then rearranging the direction of causation by applying different set of recursive zero restrictions to see if this makes a difference may not be satisfactory as this strategy may bias the results. Hence, this section introduces "simultaneity" between the financial variables. Since exchange rate is an asset price, any shock on monetary policy is expected to change its expected returns, and monetary policy may contemporaneously affect exchange rate. Similarly, a central bank aiming targets on inflation rates such as CBRT wants to react against exchange rate shocks as exchange rate is a transmission channel of foreign shocks on domestic prices. Hence, exchange rate shocks may also contemporaneously influence domestic interest rate.

ii. As in Kim and Roubini (2000) and Sim and Zha (2006), the set of zero restrictions on monetary policy reaction function is attained based on the "information delays". Monetary policy reacts after observing current value of prices and exchange rates but not the current values of outputs. Since exchange rates, interest rate and prices are available within the month but those on output are obtained quarterly, monetary policy only reacts with a lag to output changes. This assumption seems reasonable due to use of monthly data rather than quarterly data in this paper.[13]

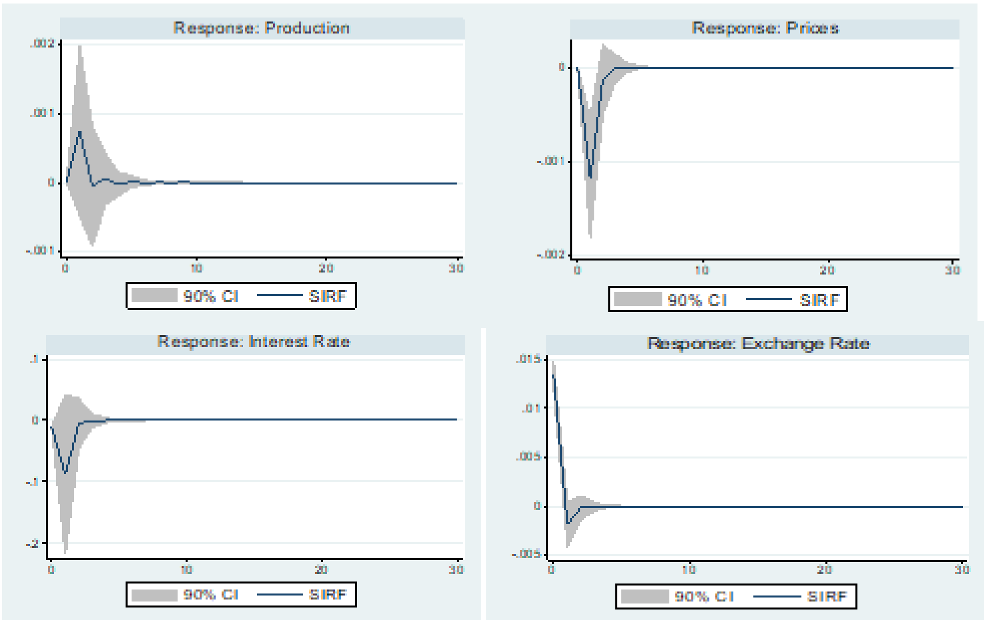
[13] I follow slightly different structural identification scheme in this section comparing to what was suggested by Kim and Roubini (2000) and Sims and Zha (2006). They indicate that monetary authority reacts contemporaneously to changes the exchange rate, but does not respond contemporaneously to changes in the prices in addition to output changes. I also imposed the same non-recursive restrictions and showed that structural impulse-responses were quite similar with the one reported in this section by Figure 6. The results are available upon request.

The following equations summarize the structural identification scheme introduced in this section:

$$\begin{pmatrix} A_{11} & 0 & 0 & 0 \\ A_{21} & A_{22} & 0 & 0 \\ 0 & A_{32} & A_{33} & A_{34} \\ A_{41} & A_{42} & A_{43} & A_{44} \end{pmatrix} \begin{pmatrix} u_{PROD_t} \\ u_{CPI_t} \\ u_{IR_t} \\ u_{REER_t} \end{pmatrix} = \begin{pmatrix} \varepsilon_{PROD_t} \\ \varepsilon_{CPI_t} \\ \varepsilon_{IR_t} \\ \varepsilon_{REER_t} \end{pmatrix} \qquad (8)$$

As seen in (8), the first two equations again characterize the lagged reaction of the real sector to shocks in the financial variables. The third equation represents the fact that the monetary authority reacts after observing the current prices and exchange rate while the last one indicates that exchange rate, being an asset price, responds contemporaneously to all the other structural shocks.

**Figure 6:** The Structural VAR, Impulse Responses to Exogenous Monetary Policy Shocks




**Note:** Figure 6 reports the structural impulse-responses of the endogenous variables to a one standard deviation exogenous monetary policy shock and 90 percent confidence intervals (grey area). The VAR model is estimated with a lag and constant.

Figure 6 graphs the structural impulse-response functions (SIRF) to a one standard deviation monetary policy shock. Unlike the baseline Cholesky identification, the monetary policy shock reduces interest rate in the short-run (i.e. expansionary monetary policy). The immediate impact is slightly negative but statistically significant. As shown in Figure 6, the impulse-response functions of output, prices, and real exchange rate with respect to an expansionary monetary policy shock in the structural VAR model are symmetric counterparts of what was found in the Cholesky identification in Figure 1. An unexpected fall in the domestic interest rate is followed by a rise in output consistent with general indication of expansionary monetary policy stance. Similar to the baseline Cholesky set-up in Figure 1, the results are still insignificant. Price responses with respect to an expansionary monetary policy shock significantly reduces in the very short-run as indication of the "price puzzle". Domestic prices fall following an expansionary monetary policy shock as the cost channel of negative innovations in domestic interest rates may reduce the borrowing cost and prices of firms.

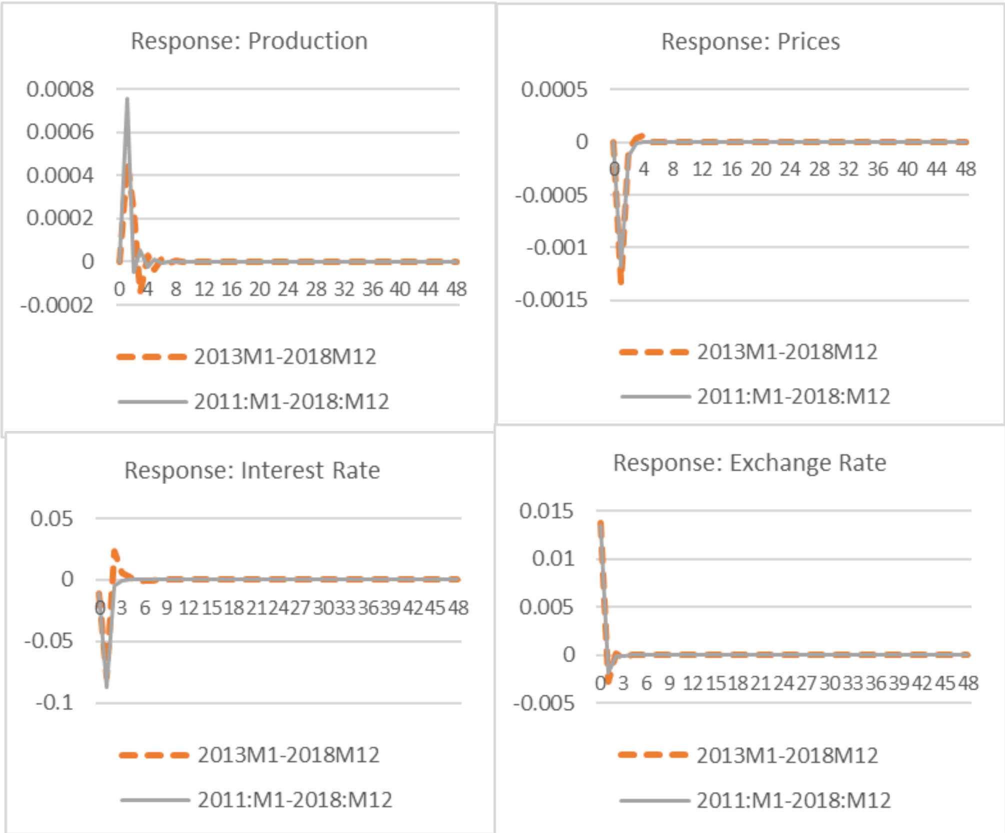
Next, I consider the effects of the monetary policy shocks on the real exchange rate. Negative innovations in domestic interest rate are initially associated with a significant appreciation impact on the real exchange rate. Following the immediate appreciation, the impact thereafter quickly disappears. The exchange rate again does move in the unexpected direction, and non-recursive structural identification also fails to solve exchange rate puzzle. The cost channel of negative innovations in interest rates which generates a decline in domestic prices may also explain the exchange rate puzzle as disinflationary shocks lead to appreciation in home currency. Consequently, the SVAR responses are consistent with what was found in recursive Cholesky identification (6) in the sense that both confirm the validity of the puzzles.[14]

Figure 7 provides robustness analysis of the structural identification results with respect to the alternative subsample, 2013:M1-2018:M12 as in Section 3.1.1. The baseline sample again refers the whole sample. Figure 7 displays the structural impulse-responses of the endogenous variables to a one standart deviation monetary policy shock over the baseline and alternative sample periods. Even though there are some minor quantitative differences, the qualitative impacts of a negative innovations in monetary policy on the endogenous variables are quite similar over the baseline and alternative sample periods.[15]

[14] Similar to baseline Cholesky identification section, Euro Area foreign variables have also been used to confirm the stability of the SVAR results (see Appendix/ Figure A2).

[15] The impulse-responses for the additional different starting point, 2015:M1 are also available upon request, and the reaction of the variables qualitatively remains same.

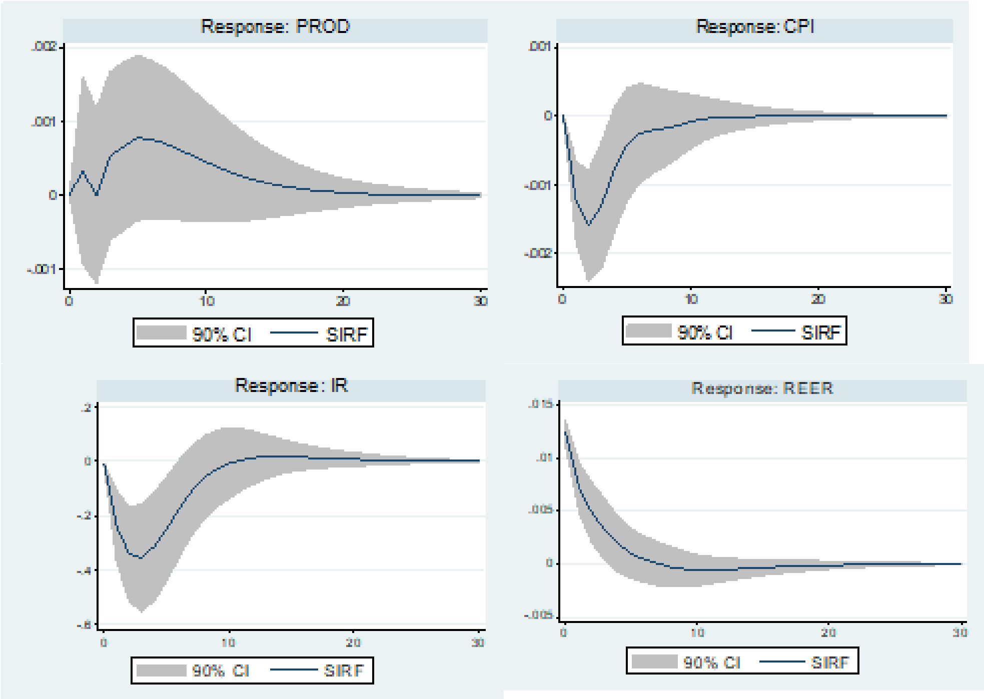
**Figure 7:** Robustness of Structural Specification: Alternative Subsample




**Note:** Figure 7 reports the structural impulse-responses of the endogenous variables to a one standart deviation exogenous monetary policy shock over the baseline and alternative sample periods. Alternative subsample VAR includes a lag and constant.

Finally, the structural impulse-responses are reproduced using all the variables in their levels when performing the VAR analysis. Figure 8 reports the structural impulse-responses with respect to an exogenous shock in monetary policy. While the structural impulse-responses react more gradually in comparison with the structural VAR model in first differences, the qualitative inferences obtained from structural VAR model in levels exhibit the same puzzling results. Overall, one can conclude that the puzzling results are quite persistent to either taking first differences or using variables in their levels in the VAR analysis.

**Figure 8:** The Structural VAR with the Variables in Levels, Impulse Responses to Exogenous Monetary Policy Shocks




**Note:** Figure 8 reports the structural impulse-responses of the endogenus variables to a one standart deviation exogenous monetary policy shock and 90 percent confidence intervals (grey area). The VAR model is estimated with two lags, a linear trend and constant. Since the modulus of each eigen-value is strictly less than one, the VAR model satisfies the stability condition.

Now, one may ask the following question: What is the reason of the puzzling results in Turkish economy? First, as pointed out earlier, the cost channel of monetary policy innovations may explain both the price and exchange rate puzzles. Second, the reason why such puzzling outcomes are observed as a response to monetary policy shock is also likely to be related to lack of “monetary policy credibility”. To cast some light on this issue, Table 1 is included to report the gap between official target inflation rates and realizations. The more the inflation targets are close to the realizations, the more the central bank is considered as credible. Since the consistently missed target rates for long periods hits the banks’ credibility, agents are likely to expect that the bank will never meet its commitments. As a result, agents’ expectations lose their capacity to convey views on credibility. This may also explain why the conducted monetary policy cannot drive the key variables as intended by the bank, and monetary policy transmission does not work properly in Turkish economy.

**Table 1:** Official Inflation Targets and Realization Rates

| **Years** | Target | Realization | Gap | **Years** | Target | Realization | Gap |
|---|---|---|---|---|---|---|---|
| **2005** | 8 | 7.7 | 0.3 | **2012** | 5 | 6.2 | -1.2 |
| **2006** | 5 | 9.7 | -4.7 | **2013** | 5 | 7.4 | -2.4 |
| **2007** | 4 | 8.4 | -4.4 | **2014** | 5 | 8.2 | -3.2 |
| **2008** | 4 | 10.1 | -6.1 | **2015** | 5 | 8.8 | -3.8 |
| **2009** | 7.5 | 6.5 | 1 | **2016** | 5 | 8.5 | -3.5 |
| **2010** | 6.5 | 6.4 | 0.1 | **2017** | 5 | 11.9 | -6.9 |
| **2011** | 5.5 | 10.4 | -4.9 | **2018** | 5 | 20.3 | -15.3 |

Source: CBRT

## 4. Conclusion

Past empirical studies looking into the impacts of monetary policies on key macroeconomic variables have often documented puzzling results. This paper empirically investigates the effects of monetary policy shocks on output, prices and real exchange rate of a small open economy Turkey using a VAR approach. The VAR model is estimated considering the sample period between 2011:M1 and 2018:M12 during which the CBRT has performed a new monetary policy framework. Since the bank has used more than one interest rate indicator through the new framework, the weighted average funding cost of the bank is employed as an indicator of the stance of the monetary policy.

Throughout the paper, two different identification schemes are performed for comparison. In Cholesky spesification, monetary policy shock is assumed to affect domestic variables with a lag while domestic shocks drive monetary policy instantenously. The recursive zero contemporaneous restrictions on the response of the financial variables are placed on the impact matrix of shocks by assuming non-simultaneity between the financial variables. The orthogonalized impulse-responses revealed that Cholesky specification exhibits exchange rate and price puzzles. Additionally, the baseline specification is extended in various ways to check the robustness of the results. This paper also performs an open economy structural VAR model to deal with the empirical anomalies encountered in the recursive identification scheme. Structural identification scheme reorganizes the identification restrictions made in the Cholesky specification and introduces two new assumptions. First, monetary policy shocks are identified without restricting the contemporaneous responses of financial variables in line with Bjørnland (2009). Second, I follow Sims and Zha (2006) and Kim and Roubini (2000) and impose a different set of zero restrictions on the monetary policy reaction function based on the "information delays". The structural responses along with the different robustness checks also confirm the validity of puzzling outcomes.

The empirical results are striking since they show that the qualitative inferences about the effects of monetary policy shocks in Turkey are quite persistent across different identification methods; a recursive identification scheme or a non-recursive one. This also provides an evidence that transmission mechanism of monetary policy does not work properly in Turkey. There might be two explanations for the emerging puzzles in Turkish economy. First, the cost channel of interest rate innovations as explained by Sims (1992) may explain both the price and exchange rate puzzles. To put it more precisely, the price puzzle may occur due to the fact that interest rate innovations may generate inflationary or disinflationary pressures that lead to price changes. Similarly, the cost channel may also explain the reason of exchange rate puzzles. That is, the positive (negative) innovations in interest rate that generates inflationary (disinflationary) pressures on domestic prices may cause an exchange rate depreciation (appreciation). Second, since the CBRT's failure on achieving the target inflation rates during the 2000's has damaged its credibility, the agents' future expectations are likely to deviate from the official commitments of the bank. This may also explain why the conducted monetary policy cannot direct the key macroeconomic variables as intended by the bank.

Finally, the achieved results somewhat differ from the past studies that centers on Turkey. As discussed in the first section, while the non-recursive literature on Turkey usually does not exhibit puzzling results, recursive literature on Turkey such as Kilinc and Tunc (2014), Civcir and Caglayan (2010) reveals different empirical anomalies. However, it should be highlighted that the past studies employ single policy rates such as overnight interest rate or interbank rates etc. which is consistent with the selected analysis periods. This study, on the other hand, reasonably employs the weighted average rate to represent the monetary policy stance of the CBRT for the selected sample period, 2011:M1-2018:M12. Usage of different analysis period and monetary policy indicator in this paper may differentiate the results from the past studies and explain why both non-recursive and recursive schemes reveal puzzling outcomes in Turkey.

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# Appendix

**Table A1:** Description of Data and Sources

| Data | Explanation | Data Source |
|---|---|---|
| PROD: Industry Production Index for Turkey (2015=100) | seasonally adjusted by official source and expressed in logs. | Federal Reserve Bank of St. Louis (FRED) |
| CPI: Consumer Price Index for Turkey (2015=100) | seasonally adjusted by Holt-Winters and expressed in logs . | the CBRT's Electronic Data Delivery System (EDDS) |
| IR: Domestic Interest Rates (Percent) | Weighted Average Funding Cost of the CBRT (WAFC) | EDDS |
| REER: Real Effective Exchange Rate for Turkey (2015=100) | seasonally adjusted by Holt-Winters and expressed in logs. The exchange rate is specified so that an increase implies appreciation of home currency | FRED |
| USPROD: Industrial Production Index for the US (2015=100) | seasonally adjusted by official source and expressed in logs | FRED |
| WCPI: World Price Index for all Commodities (2015=100) | seasonally adjusted by Holt-Winters and expressed in logs | FRED |
| FED: Federal Funds Rate (Percent) | | FRED |
| EAPROD: Industrial Production Index for Euro Area (2015=100) | seasonally adjusted by official source and expressed in logs. | OECD |
| EAIR: EURO Area Interest Rate (Percent) | | FRED |

**Table A2:** Phillips–Perron (PP) Unit Root Test Results

| | **Level**<br>**PP with trend and constant** | **First Differences (Δ)**<br>**PP with constant** |
|---|---|---|
| **PROD** | -3.722** | -16.335*** |
| **CPI** | -0.176 | -7.142*** |
| **IR** | 0.207 | -8.076*** |
| **REER** | -2.502 | -9.809*** |
| **WCPI** | -1.684 | -7.293*** |
| **USPROD** | -1.252 | -9.413*** |
| **FED** | 2.057 | -6.776*** |
| **EAIR** | -1.710 | -8.549*** |
| **EAPROD** | -2.307 | -13.324*** |

**Notes:** Phillips-Perron (1988) unit root test is performed to investigate the stationarity properties of the variables. The test uses Newey-West heteroscedasticity and autocorrelation consistent (HAC) covariance estimator. When testing a variable in level, both a constant and a time trend are included. When testing a variable in first differences, only a constant is included. ***, ** and * denote significance at 1%, 5% and 10 % significance levels. For the case with constant and trend, critical values for PP test are -4.05, -3.45, and -3.15 for 1 %, 5 % and 10 % significance levels, respectively. For the case with constant, critical values for PP test are -3.51, -2.89, -2.58 for 1 %, 5 % and 10 % significance levels, respectively. The null hypothesis that PROD variable in level contains a unit root can not be rejected at 1% significance level. The estimated Newey-West lag truncation parameter is three.

**Table A3:** Eigenvalue Stability Condition

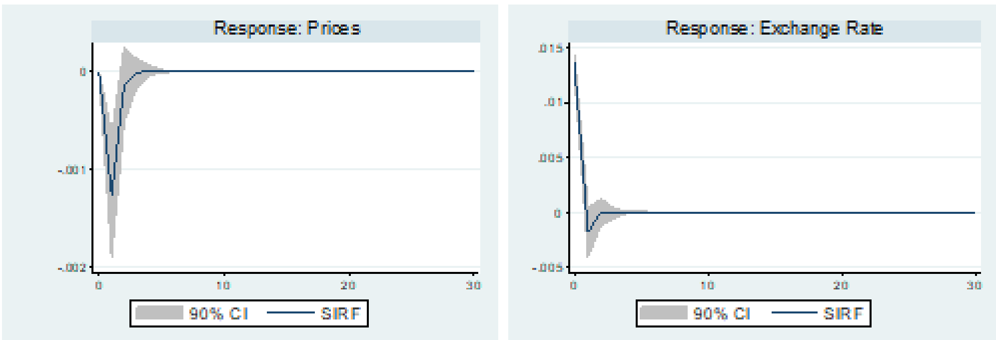
| Eigenvalue | Modulus |
|---|---|
| -.4668836 | .466884 |
| .1008782 + .1096236i | .148976 |
| .1008782 - .1096236i | .148976 |
| -.1256336 | .125634 |

**Note:** The estimates satisfy the eigenvalue stability condition since the modulus of each eigenvalue is strictly less than 1.

**Figure A1:** Baseline Cholesky Specification, Impulse Responses to Exogenous Monetary Policy Shocks, Euro Area Foreign Variables


**Notes:** Figure A1 only reports the orthogonalized impulse-responses of the exchange rates and prices with respect to possitive innovations in monetary policy in order to save space. The VAR model with a lag and constant satisfies the stability condition.

**Figure A2:** The Structural VAR, Impulse Responses to Exogenous Monetary Policy Shocks, Euro Area Foreign Variables




**Note:** Figure A1 only reports the structural impulse-responses of the exchange rates and prices with respect to negative innovations in monetary policy in order to save space. The VAR model with a lag and constant satisfies the stability condition.