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Possible effects of domestic and foreign factors on monetary policy implementation in Turkey: a DSGE-VAR approach

Oguzhan Ozcelebi*, Nurtac Yildirim and Aydan Kansu

Department of Economics, Faculty of Economics, Beyazit Campus, Istanbul University, 34452, Fatih, Istanbul, Turkey

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In this paper, we attempt to explore the possible effects of technology, foreign output, price and terms of trade shocks on short-term interest rates in Turkey within a dynamic stochastic general equilibrium-vector autoregressive (DSGE-VAR) framework. In a sense, the primary aim of our paper is to analyse whether the Central Bank of the Republic of Turkey (CBRT) should consider the role of technology, foreign output, price and terms of trade shocks in its monetary policy implementation. Empirical results reveal that the above-mentioned factors have importance for the CBRT, which intends to control economy-wide interest rates in order to maintain price stability.

Keywords: foreign shocks; domestic shocks; short-term interest rates; monetary policy; DSGE-VAR model

JEL classification: E17, E30, F41

1. Introduction

A well-known monetary policy rule proposed by Taylor (1993) has tended to be pursued by several central banks and policymakers to assess monetary policy performance since it was commonly acknowledged that monetary policy rules outperform discretionary policies. However, in the face of the fact that the economic environment has been changing with the ever-evolving globalisation process and technological developments that affect specifically financial markets, the original Taylor rule has proved insufficient to explain the overall considerations underlying the interest rate setting behaviour of central banks. Several economists and policy makers have then provided a number of modifications of the Taylor-type reaction functions with additional explanatory variables and some changes to existing ones. First, Taylor (1993) used the GDP deflator as a measure of inflation in original reaction functions while later modifications tend to use different measures of inflation such as personal consumer expenditure price index, consumer price index (CPI) inflation, core CPI inflation, GDP price inflation and expected inflation (Billi, 2009; Kozicki, 1999). Second, the original formulation of the Taylor rule was designed as a linear form, with standard weights (0.5) put on inflation and output gaps while nonlinear versions of the Taylor rule assign different weights to the deviations of inflation and output from their targeted levels (Cukierman & Muscatelli, 2008; Dolado, Maria-Dolores, & Naveria, 2005; Gerlach, 2000; Klose, 2011). Third, a

*Corresponding author. Email: ogozc@istanbul.edu.tr

forward-looking Taylor rule with a wider set of information on anticipated values of variables has been designed instead of the standard form of Taylor rule, which embedded actual lagged values of inflation and output (Clarida, Gali, & Gertler, 1998, 2000).

The original Taylor rule has also been modified so as to include additional variables such as changes in asset prices (Belke & Polleit, 2007; Bernanke & Gertler, 1999; Botzen & Marey, 2010; Cecchetti, Genberg, Lipsky, & Wadhwani, 2000; Clarida, Gali, & Gertler, 1998; Fernandez, Koenig, & Nikolsko-Rzhevskyy, 2010; Fuhrer & Tootell, 2008; Hoffmann, 2013; Rigobon & Sack, 2003; Semmler & Zhang, 2003; Smets, 1997), variations in long-term interest rates (Clarida, Gali, & Gertler, 1998, 2000; Goodfriend, 1998; Jones & Kulish, 2013; Smets, 1997; Yüksel, Metin-Ozcan, & Hatipoglu, 2013) and exchange rates (Ball, 1999, 2000; Berger & Kempa, 2012; Chen & Chou, 2012; Engel & West, 2006; Galí & Monacelli, 2005; Galimberti & Moura, 2013; Hoffmann, 2013; Kempa & Wilde, 2011; Lubik & Schorfheide, 2007; Molodtsova, Nikolsko-Rzhevskyy, & Papell, 2008; Molodtsova & Papell, 2009; Svensson, 2000; Taylor, 2001; Wilde, 2012), among others, into the monetary reaction functions so as to provide a wider explanation to movements in interest rates. On the other hand, this framework may still lack the ability to capture the dynamics of short-term interest rates relating to the accelerating process of globalisation and openness to external shocks which confronted central banks with challenging economic conditions.

In this study, we employed dynamic stochastic general equilibrium-vector autoregressive (DSGE-VAR) models to analyse the role of domestic and foreign macroeconomic factors influencing short-term interest rates in an open economy framework for the case of Turkey. More precisely, we aim to investigate the effects of technology, foreign output, price and terms of trade shocks on short-term interest rates parallel to the theoretical framework of Galí and Monacelli (2005) and Lubik and Schorfheide (2007). Accordingly, we analyse whether the Central Bank of the Republic of Turkey (CBRT), which intends to control economy-wide interest rates, should take into account the possible effects of these shocks on short-term interest rates when implementing monetary policy. Galí and Monacelli (2005) show the macroeconomic implications of monetary policy rules for the small open economy while, similarly, Lubik and Schorfheide (2007) only estimate the parameters of the DSGE model and aim to seek an answer to whether changes in exchange rates have an impact on monetary policy implementation. Our study differs from Lubik and Schorfheide (2007) in that we not only estimate the model parameters, but also compute the effects of technology, foreign output, price and terms of trade shocks on short-term interest rates in Turkey with impulse response and forecast error variance decompositions deriving from DSGE-VAR model estimation. Thereby, the main contribution of our study to the existing literature is the discussion of possible consequences of these shocks on monetary policy implementation in Turkey.

The rest of the paper is organised as follows. Section 2 evaluates the effect of the dynamics of the Turkish economy in the liberalisation period on monetary policy decisions. Section 3 introduces the theoretical and empirical methodology of the study. The empirical results and findings of the paper are discussed briefly in Section 4. Section 5 concludes and discusses some policy implications.

2. The case of Turkey's economy

Turkey, as an emerging market, is an important case to be studied since CBRT has made significant monetary policy changes in terms of the exchange rate regime over the past few decades due to the effects of domestic and external shocks. There have been major changes in monetary and exchange rate policies since the liberalisation period in the 1980s and these changes have affected macroeconomic variables. With the so-called 24 Ocak 1980 economic policy changes, the liberalisation process of the Turkish economy started. Within this framework, the exchange market was deregulated and then capital movements were liberalised. However, the economy became more fragile and prone to crisis owing to the early liberalisation of capital flows before strengthening of the capital market. The 1994 crisis was a crucial point for the monetary policy of the CBRT. As stated by Ozdemir and Turner (2004), the CBRT utilised open market operations and created Turkish Lira through exchange transactions in order to control liquidity and defend the economy against speculative attacks after the 1994 crisis. Additionally, implementation of a crawling band exchange rate regime started after the 1994 crisis (Berument & Pasaogullari, 2003). The main reason for the 1994 economic crisis in Turkey was that public debt was not sustainable in an environment of high inflation along with unstable growth performance and structural problems in financial markets. As a result, the factors caused instability in the Turkish economy and shortened maturity for investors and savings.

Due to its geopolitical importance, Turkey has also experienced a greater influence of international forces on its economic policy setting and macroeconomic variables. Within this context, the Turkish government announced its own national programme for the adoption of the *Acquis communautaire* or the European Union (EU) *Acquis* on 19 March 2001 after Turkey was recognised as a candidate EU state at the Helsinki European Council in 1999. Subsequently, in an effort to harmonise its policy structures with those of the EU, Turkey determined its monetary policy, fiscal policy and exchange rate policy in accordance with the Maastricht criteria to adopt the EU's single currency, the euro. In line with the objective of reducing inflation permanently, implementation of a currency peg exchange rate regime began. However, the rising current account deficit and real appreciation of Turkish lira increased the fragility of the Turkish economy. An important part of the current account deficit arose from the external shocks, namely the rising oil prices and appreciation of the US dollar against major European currencies. Risks related to the Turkish economy have also become diversified with the fragile banking system (currency and maturity mismatches and rise in non-performing loans). All of these factors were sufficient enough for an economic crisis in Turkey and the February economic crisis in 2001 was trigged by a political crisis leading to GDP contraction, an increase in public sector borrowing requirements (PSBR) and a high inflation rate, as shown in Table 1.

The impact of both domestic and foreign macroeconomic shocks upon short-term interest rates has significantly emerged in Turkey as a consequence of the 2001 economic crisis after the monetary policy changes with the abolition of the currency peg and transition into a floating currency regime and the implementation of inflation targeting strategy. Moreover, in an effort to harmonise its policy structures with those of the EU, at the beginning of 2002, the CBRT began to implement inflation targeting, which was inclined toward the use of short-term interest rates in accordance with the floating exchange rate regime since it is efficient under domestic and foreign shocks. In parallel with the price stability objective, the CBRT started to use short-term interest rates as a basic policy tool. As a result of the inflation targeting regime, accompanied by fiscal discipline, inflation and interest gradually decreased in Turkey. However, the 2007–2008 financial crisis negatively affected Turkish economic activity and GDP decreased by 4.8% in 2009. Since the volatility of cross-border capital flows increased after the 2007–2008 global crisis, specifically in the emerging markets, such as Turkey, many

Table 1. Major economic indicators of Turkey.

Years	GDP Growth (%)	Annual consumer price inflation (%)	PSBR/GDP (%)	Current Account Deficit/GDP (%)
1999	−3.4	64.9	12	−0.4
2000	6.8	54.9	9	−3.7
2001	−5.7	54.4	12	2.0
2002	6.2	45.0	10	−0.3
2003	5.3	25.3	7	−2.5
2004	9.4	10.6	4	−3.6
2005	8.4	10.1	0	−4.4
2006	6.9	9.6	−2	−6.0
2007	4.7	8.8	0	−5.8
2008	0.7	10.4	2	−5.4
2009	−4.8	6.3	5	−1.9
2010	9.2	8.6	2	−6.1
2011	8.8	6.5	0	−9.6
2012	2.1	8.9	1	−6.2
2013	4.0	7.5	1	−7.9

Source: CBRT and Federal Reserve Bank of St. Louis databases. Author calculation.

central banks started to change their policy tools in order to control the current account, exchange rate and credit growth. In Turkey, the CBRT has initiated a new mixed policy tool that consists of an asymmetric interest rate corridor controlling foreign fund supply and a reserve option mechanism managing the foreign fund demand (Aysan, Fendoğlu, & Kilinç, 2014). In this way, the CBRT considers price stability as the main objective and financial stability as the supportive objective. Concerns about raising the short-term interest rates to maintain price stability, which would prompt exchange rate appreciation and trigger financial stability, were the reasons for policy tool diversification. In other words, the traditional view of monetary policy of the CBRT changed after the global crisis and the CBRT started to implement more flexible monetary policy to fight against external shocks (Eşkinat, 2013). In this context, there have been some studies investigating whether the CBRT followed the Taylor rule during the crises period. Aklan and Nargelecekenler (2008) showed that for the period of 2001–2006, the CBRT followed the Taylor rule in interest rate setting. Erdem and Kayhan (2011) investigated the short-term interest rate decisions of the CBRT and changes in macroeconomic variables using Taylor type policy reaction functions for two periods. The findings of this study revealed that from January 2002 to March 2006 the policy of the CBRT was not consistent with the pure Taylor rule, in contrast to the findings of Aklan and Nargelecekenler (2008), however during the period from April 2006 to November 2009 the CBRT followed a pure Taylor rule. Erdem and Kayhan (2011) pointed out that for the period of 2006–2009, the CBRT considered the output gap movements and exchange rate fluctuations in short-term interest rate decisions. Uslu and Özçam (2014) also examined this issue for the period of 2003–2012 and the results showed that CBRT did not follow a strict Taylor rule.

As for the so-called 24 Ocak 1980 economic policy changes, the year 2002, when inflation targeting within the context of the Taylor rule had begun implementation, can be recognised as a significant year for regime change in terms of monetary policy stance. Thus, the year 2002 could have led to structural breaks in short interest rate series in Turkey. We tested whether the year 2002 caused a structural break in the dynamics of a short interest rate, upon which we developed our empirical analysis.

Since DSGE models derived from economic theory can be used to define all the linkages between short-term interest rates and domestic and foreign macroeconomic variables, we attempt to fill the gap in the literature by analysing the role of domestic and foreign macroeconomic shocks influencing short-term interest rates for the case of Turkey with the DSGE-VAR model's impulse response and forecast error variance decompositions. When the alternative specifications of the Taylor rule are considered, our study focuses on the factors overlooked in Taylor's monetary policy rule with responses to inflation, output gap and exchange rate. Within this framework, we defined a set of equations, namely the monetary policy reaction function, as well as the New Keynesian Phillips curve and IS curve. These equations were considered in our DSGE-VAR model estimation, where we show the role of technology and foreign shocks on short-term interest rates in Turkey.

3. Theoretical and empirical framework

Since the pioneering work of Sims (1980), VAR models have been widely used by researchers to analyse macroeconomic dynamics. However, the basic VAR is unable to expose the detailed structure of shocks as it is a 'reduced-form' model. In order to unpack the shocks hitting the system and their effects on the economy, time series models should be identified with extra assumptions. Within this context, DSGE models derived from economic theory can be used to define all the linkages between variables (Liu & Theodoridis, 2010) as is evident from a growing literature in DSGE-VAR models (Chow, Lim, & McNelis, 2014; Chow & McNelis, 2010; Del Negro & Schorfheide, 2004; Franchi & Paruolo, 2012; Ghent, 2009; Lees, Matheson, & Smith, 2007; Liu, Gupta, & Schaling, 2008; Liu & Theodoridis, 2010; Morris, 2012; Watanabe, 2009).

3.1. The economic model

In line with the aim of our study, our economic model consists of three major equations, namely a monetary policy reaction function, New Keynesian Phillips curve and IS curve, all of which are forward-looking in nature. Our monetary policy reaction function formulation includes the exchange rate, which is introduced under the purchasing power parity (PPP) assumption. On the other hand, foreign factors, world output, terms of trade and foreign inflation, are incorporated into the system since open economies can engage in intertemporal as well as intratemporal trade for the purpose of smoothing consumption, as suggested by Lubik and Schorfheide (2007).

We define a linear monetary policy reaction function with forward-looking behaviour where the central bank chooses its policy according to the expected inflation $E\pi_{t+1}$ and deviations of output from its potential level $\bar{y}_t$ and nominal exchange rate depreciation Δe_t.[1] Thus, the target or policy interest rate r_t^T is assumed to be determined as below:

$$r_t^T = [\delta + \psi_1(E\pi_{t+1}) + \psi_2(y_t - \bar{y}_t) + \psi_3\Delta e_t] \tag{1}$$

where ψ_1, ψ_2 and ψ_3 are policy coefficients. δ is a coefficient denoting the long-run equilibrium nominal interest rate. When the short-term interest rate (r_t) is assumed to follow the path $r_t = (1 - \rho_R)r_t^T + \rho_R r_{t-1} + \varepsilon_{r,t}$, the policy rule with interest-rate inertia can be expressed as below:

$$r_t = \rho_R r_{t-1} + (1 - \rho_R)[\delta + \psi_1(E\pi_{t+1}) + \psi_2(y_t - \bar{y}_t) + \psi_3\Delta e_t] + \varepsilon_{r,t} \tag{2}$$

where $\varepsilon_{r,t}$ is the unsystematic component of the monetary policy. $\rho \in [0, 1]$ captures the degree of the interest rate smoothing. We summarised the response of the monetary policy authority to the changes in inflation and other macroeconomic variables (output gap and exchange rates) as in the equations above. On the other hand, in order to understand the dynamics of inflation, some modifications of the Phillips curve have been used by researchers and policymakers. The Phillips curve with forward-looking behaviour indicates that the current inflation rate is affected by the expected inflation. Accordingly, a higher/lower expectation of future inflation leads to a higher/lower current inflation (Semmler, Greiner, & Zhang, 2003, p. 10). Similar to Mihailov, Rumler, and Scharler (2011), our New Keynesian Phillips curve specification including terms of trade is expressed as below:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa(y_t - \bar{y}_t) + \alpha E_t \Delta q_t \tag{3}$$

where $\kappa > 0$ is a function of factors such as labour supply and demand elasticities and parameters measuring the degree of price stickiness.[2] Increases in output gap and expectations related to the terms of trade lead to an increase in the current inflation.

Along with the classical Philips curve approach, IS equations can be modified by the inclusion of expectations. An IS curve with forward-looking behaviour differs from the traditional one in that current output depends on expected future output and inflation as well as the interest rate. Accordingly, it is expected that economic agents prefer to smooth consumption; expectation of higher/lower consumption in the subsequent period leads them to consume more/less in the current period and thus current output rises. Similarly, if individuals expect the inflation rate to increase/decrease in the future, they will consume more/less today, which in turn raises/lowers the current inflation rate (Semmler, Greiner, & Zhang, 2003, p.10). Our formulation also includes technology and terms of trade as a determinant of current output. Within this context, we specify the IS curve as in equation (4), similar to Galí and Monacelli (2005) and Lubik and Schorfheide (2007);[3]

$$y_t = E_t y_{t+1} - [\tau + \alpha(2-\alpha)(1-\tau)](R_t - E_t \pi_{t+1}) - \rho_z z_t - \alpha[\tau + \alpha(2-\alpha)(1-\tau)]E_t \Delta q_{t+1} + \frac{\alpha(2-\alpha)(1-\tau)}{\tau} E_t \Delta y^*_{t+1} \tag{4}$$

In equation (4), $0 < \alpha < 1$ is the import share and $\tau^{-1} > 0$ denotes the intertemporal substitution elasticity.[4] Endogenous variables of the IS curve are aggregate output (y_t) and the CPI inflation rate (π_t), whereas z_t is technology growth, q_t is the terms of trade[5] and y^*_t is exogenous world output.[6]

3.2. DSGE-VAR model representation

The DSGE-VAR model is based on the basic VAR model as represented below:

$$y_t = \Phi_0 x_0 + \sum_{j=1}^{p} \Phi_j y_{t-j} + \varepsilon_t, t = 1, ..., T \tag{5}$$

where $\varepsilon_t \sim N_n(0, \Sigma_\varepsilon)$. Φ_0 is an $(n \times k)$ matrix, while the matrix (Φ_j) is $(n \times n)$ for $j = 1, ..., p$. x_t is a p dimensional covariance stationary vector stochastic process,[7] while y_t is $(n \times 1)$. When the vector $y_t = [x'_t y'_{t-1} \cdots y'_{t-p}]'$ has dimension $(np + k)$ and the matrix $\Phi = [\Phi_0 \Phi_1 \cdots \Phi_p]$ is of dimension $n \times (np + k)$. The VAR model can be expressed as (Warne, 2012):

$$y_t = \Phi Y_t + \varepsilon_t \tag{6}$$

3.2.1. Identifying structural shocks of the DSGE-VAR impulse response functions

Estimation of DSGE-VAR requires the identification of structural shocks to the model similar to structural vector autoregression (SVAR) models.[8] If we assume that $\upsilon_t \sim N_n(0, I_n)$ represent these shocks, they are related to the VAR residuals ε_t through;

$$\varepsilon_t = A_0 \upsilon_t \tag{7}$$

Within this framework, A_0 is the $(n \times n)$ dimensional matrix and each column is equal to the contemporaneous response in y_t from a unit impulse to the corresponding element of υ_t. For the identification of structural shocks $n(n-1)/2$ restrictions need to be imposed in addition to the $n(n+1)/2$ restrictions that are imposed through the assumed covariance matrix of υ_t (Warne, 2012).

If ε_t is substituted in equation (5) using equation (7), the shocks are defined as:

$$\upsilon_t = A_0^{-1} y_t - \sum_{j=1}^{p} A_0^{-1} \Phi_j y_{t-j} - A_0^{-1} \Phi_0 x_t, t = 1, \ldots, T, \tag{8}$$

where $A_0^{-1} \Phi_j y_{t-j}$. When the structural shocks, υ_t, are identified, the responses of endogenous variables to these shocks can be computed as:

$$Y_t = J_p \Phi_0 x_t + \Psi Y_{t-1} + J_p A_0 \upsilon_t \tag{9}$$

where the vector $Y_t = [y_t' \cdots y_{t-p+1}']'$ is $(np \times 1)$ dimensional, while the matrix J_p has dimension $(np \times p)$ with I_n on top and zeros below such that $y_t = J_p' Y_t$. From equation (9), the responses of the endogenous variables are specified (Warne, 2012):

$$\text{resp}(y_{t+h} | \upsilon_t = e_j) = J_p' \Psi^h J_p A_0 e_j, h \geqslant 0 \tag{10}$$

3.2.2. Forecast error variance decompositions

Forecast error variance decomposition in DSGE-VAR models can be estimated in a manner similar to that used for other VAR models.[9] If $R_i = J_p' \Psi^i J_p A_0$ is the $n \times n$ matrix with all impulse responses in y for period i, the long-run forecast error variance decomposition can be expressed as (Warne, 2012):

$$R_{lr} = \sum_{i=0}^{\infty} J_p' \Psi^i J_p A_0 = J_p' (I_{np} - \Psi)^{-1} J_p A_0 \tag{11}$$

3.3. Data

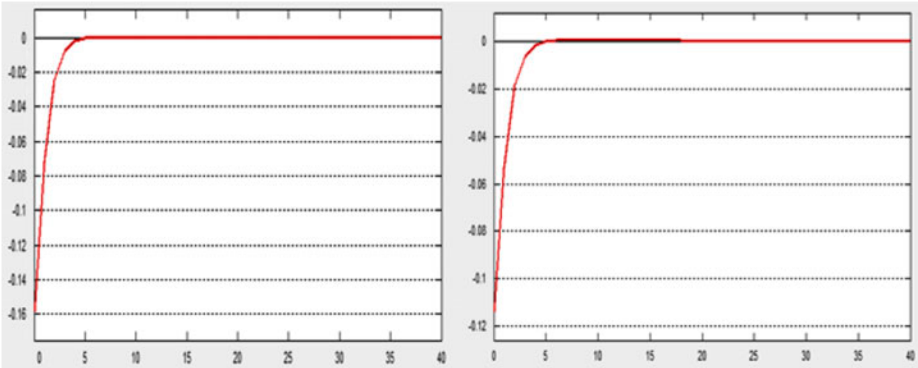
In accordance with the aim of our study, we carried out an empirical exercise by using data at quarterly frequencies from 1998:1 to 2013:4 due to data availability for the case of Turkey. The real GDP is seasonally adjusted with the base year (2010) = 100, whereas the CPI measures the percentage change from the previous period. The short-term interest rate is proxied by the overnight interbank rate. As for the nominal exchange rate variable, we computed a nominal exchange rate index with the base year (2010) = 100 expressed in logarithms by using nominal exchange rate defined in units of Turkish lira (TRY) per unit of US dollar ($). The terms of trade variable is measured as the (log-) ratio of export and import price indices. World output and inflation, technological progress and terms of trade are exogenous processes whereas the terms of trade variable is treated as endogenous as suggested by Lubik and Schorfheide (2007). The time series were extracted from OECD and CBRT databases.[10] All series incorporated in the empirical exercise are seasonally adjusted and estimations were carried out by using MATLAB routines.

There were monetary policy changes in Turkey during the period under study, however the year 2002 coincides with a major monetary policy regime change in Turkey as summarised in Section 1. On the other hand, we applied a unit root (UR) test[11] with a structural break to the overnight interbank rate series to determine the date that led to a shift in the overnight interbank rate series. The test pointed out that 2003:02 caused a structural break in the overnight interbank rate series. Considering the statistical finding related to the overnight interbank rate series and the importance of the year 2002 for the Turkish economy in terms of monetary policy change, two DSGE-VAR models were estimated due to statistical and economic reasons. Model 1 considers the period from 1998:1 to 2013:4, while Model 2 was computed from the period 2002:1 to 2013:4.

4. Empirical results

For the empirical analysis, we employed DSGE-VAR modelling according to the theoretical framework presented in Section 2.1. The variables (y_t, π_t, r_t, q_t, Δe_t) form a linear rational expectations model, where we applied the marginal posterior mode estimation routine for the DSGE-VAR model. A lag order of 4 was selected for both Model 1 and 2 so that the model with the largest marginal likelihood is chosen. The DSGE-VAR model was identified by selecting state shocks equal to the number of endogenous variables (r_t, z_t, y_t^*, π_t^*, q_t). We incorporated priors into the estimation process similar but not identical to Lubik and Schorfheide (2007).[12] Models 1 and 2 are solved with Anderson and Moore's algorithm; both models use DSGE-VAR marginal posterior as an estimator, the λ hyperparameter is set to infinity and the inverse Hessian estimator was employed as the optimisation routine.[13] Thus, we attempted to compute the response of the overnight interbank rate to one standard deviation shock in technology, foreign output and price and terms of trade and perform forecast error variance decomposition analysis of overnight interbank rate series. Thereby, we compared the results of impulse response and forecast error variance decomposition of the two DSGE-VAR models.

According to the neoclassical growth models, technological progress is a major factor influencing long-run economic growth as well as capital accumulation and population growth. Technological progress may also decrease production costs and thus may have a role in decreasing inflation as examined by Mincer and Danninger (2000), Stalder (2001), Storm and Naastepad (2009), McAdam and Willman (2011) and Alani (2012). Therefore, technology shocks may have had an indirect impact on the CBRT's policy interest rate, determined in response to changes in output and inflation. Figure 1 shows that the overnight interbank rate fell following a one standard deviation shock in technology and the influence can be regarded as temporary since it lasts up to the fifth quarter in Models 1 and 2, which is consistent with the finding of Lubik and Schorfheide (2007). On the other hand, the effect of technology shocks on the overnight interbank rate were relatively long-lived; the overnight interbank rate fell up to the following 40th quarter. Both models expose the negative relationship between technological progress and inflation in Turkey, consistent with the outcome of studies by Mincer and Danninger (2000) and Stalder (2001), and in contrast to Alani (2012) who found

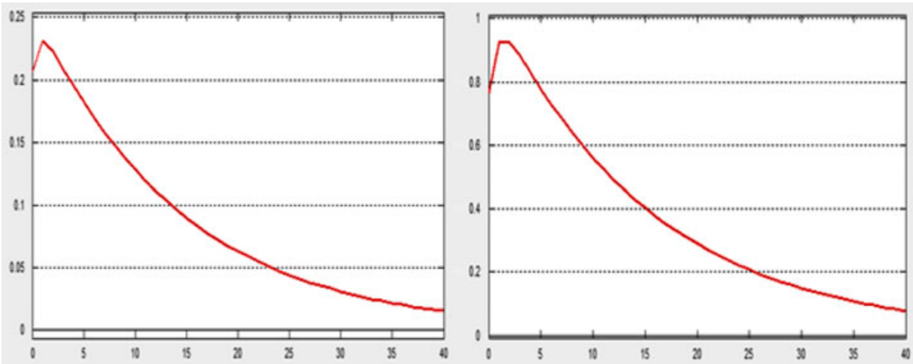


(a) Model 1(1998:1 to 2013:4) (b) Model 2 (2002:1 to 2013:4)

Figure 1. Original response of (r_t) to $\varepsilon_{z,t}$.
Source: Authors' calculation.

that technological progress could have led to production of more competitive goods that could be sold at prices above similar goods in the domestic markets. Our finding stresses that the effects of a decrease in production costs become more persistent compared with the effects of an increase in production in Turkey. Thus, the CBRT reduced its policy interest rate, which in turn led to a decrease in short-term interest rates. It can also be inferred that the monetary policy regime change in 2002 did not have any determinative role on the relationship between technology shocks and short-term interest rates. On the other hand, our findings provide evidence for the implication that the structural dynamics of the Turkish economy, more precisely the production structure, had not changed significantly enough to influence the outcomes of technology shocks.

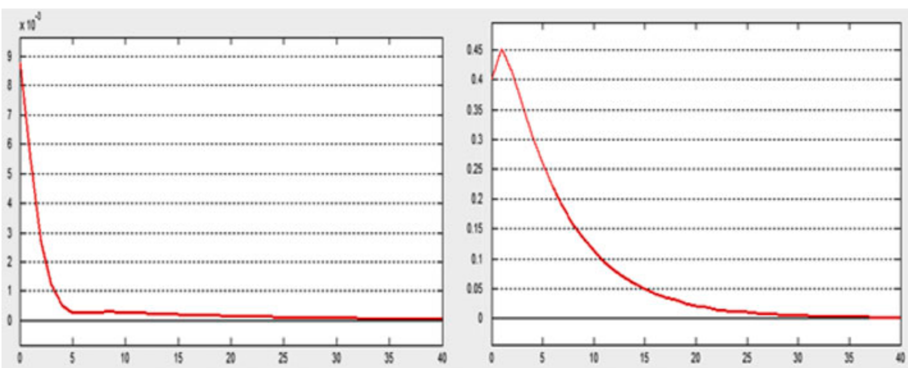
In the wake of economic globalisation phenomena, the analysis of the effects of foreign shocks on a domestic economy has become more important, as supported by the outcomes of a number of studies (Adolfson, Laséen, Lindé, & Villani, 2007a, 2007b; Adolfson, Lindé, & Villani, 2006; Alba, Su, & Chia, 2011; Alp & Elekdağ, 2011; Backus, Kehoe, & Kydland, 1992; Baxter & Crucini, 1995; Berkelmans, 2005; Berument & Kilinc, 2004; Bodenstein, Erceg, & Guerrieri, 2009; Jiménez-Rodríguez, Morales-Zumaquero, Égert, 2010; Lubik & Schorfheide, 2007). As the world's economies have become more interconnected, volumes of foreign trade among countries have expanded, and thus changes in foreign economic activity affect the demand for export goods. Then, prices of export goods increase/decrease, which in turn affect the general price levels in the domestic economy. According to Figure 2, a long-lived effect on overnight interbank rate was detected by both models following a one standard deviation shock in foreign output level. This finding is in line with that of Lubik and Schorfheide (2007) and Alba, Su, & Chia, (2011), implying that changes in foreign output as an external shock may have a permanent effect on economic activity in Turkey consistent with the findings of Berument and Kilinc (2004). On the other hand, the coefficient of foreign output level shock is relatively higher in Model 2, demonstrating that foreign output shocks were seriously taken into consideration by the CBRT after the inflation targeting regime. It can also be interpreted that CBRT's monetary policy may essentially be under the influence of foreign economic activity as found by Alp and Elekdağ (2011), thus the CBRT should closely monitor the level of economic activity in the world and implement its policy accordingly.



(a) Model 1(1998:1 to 2013:4) (b) Model 2 (2002:1 to 2013:4)

Figure 2. Original response of (r_t) to $\varepsilon_{y^*,t}$.
Source: Authors' calculation.

On the other hand, any impact of foreign or domestic conditions on prices is expected to influence the export and the domestic prices of a good as stated by Kravis and Lipsey (1977). Within this context, increases in the foreign price level may affect the domestic price level via the prices of imported goods as detected by Ferrucci, Jiménez-Rodríguez and Onorante (2010), Lipińska and Millard (2011) and Hamilton (2012). Since increases in the prices of imported goods may lead to inflationary pressures on domestic prices, central banks may consider the role of foreign price shocks in their monetary policy implementation. Figure 3 shows that as a result of a one standard deviation shock in foreign price level, both models detect short-term interest rate decreases sharply in line with the finding of Lubik and Schorfheide (2007). However, the coefficient of foreign inflation shocks is relatively smaller in Model 2, as shown in Figure 3, pointing to the fact that the CBRT has focused on business cycles of foreign countries rather than foreign price dynamics when compared with our finding related to the impacts of foreign output shocks. Nevertheless, our findings reveal that the CBRT



(a) Model 1(1998:1 to 2013:4) (b) Model 2 (2002:1 to 2013:4)

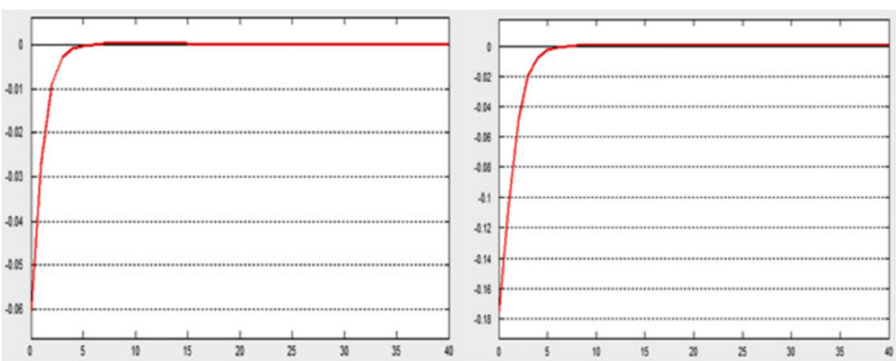
Figure 3. Original response of (r_t) to $\varepsilon_{\pi^*,t}$.
Source: Authors' calculation.

determines its policy interest rate in accordance with the trends in foreign price level and thus the overnight interbank rate may be influenced. Hence, it is critically important for the CBRT to clarify the channels through which the foreign price level influences the domestic price level by using quantitative techniques.

It is theoretically accepted that an improvement in the terms of trade increases real income, thereby raising savings and investment, leading to an improvement of the current account balance. Thus, changes in current account balance reflect the need for quantities of foreign resources that should be borrowed to fund investment. In addition, the current account deficit is a major factor influencing risk perception and causing global imbalances (Acharya & Schnabl, 2010; Bernanke, 1995; Borio & Disyatat, 2011; Dullien, 2010; Eichengreen, 2009). Figure 4 shows that as a result of a one standard deviation shock in terms of trade, implying improvement in terms of trade and thus current account balance, the overnight interbank rate decreased. However, the negative effect is not long-lived in Models 1 and 2, persisting to the fifth quarter in line with the finding of Lubik and Schorfheide (2007). More precisely, it can be asserted that the CBRT considered the factors leading to changes in terms of trade when determining the policy rate despite our finding that terms of trade shocks have short-term effects on the dynamics of the overnight interbank rate. Consequently, we find a positive relationship between current account deficit and interest rate, revealing that an improvement in the terms of trade lowers the need for foreign resources to fund investments and leads to a fall in short-term interest rates as stated by Eicher, Schubert, and Turnovsky (2008). Since the short-term interest rate falls, our finding also indicates that risk perception decreases due to the improvement of terms of trade.

Forecast error variance decomposition analysis was also performed to determine the degree of importance of endogenous variables for the overnight interbank rate for the following 40 quarters. Thereby, the long-run variance of short-term interest is decomposed in the long run.

According to Table 2, the overnight interbank rate explains approximately 35% of the variation in itself up to the 40th quarter, while shocks in the overnight interbank rate account for approximately 10% of the variation in itself in Model 2. It can be asserted from both models that the short-term interest rate has an important explanatory power



(a) Model 1(1998:1 to 2013:4) (b) Model 2 (2002:1 to 2013:4)

Figure 4. Original response of (r_t) to $\varepsilon_{q,t}$.
Source: Authors' calculation.

Table 2. Forecast error variance decomposition results of r_t (models 1 and 2).

Forecast horizon		Shocks				
		$\varepsilon_{r,t}$	$\varepsilon_{z,t}$	$\varepsilon_{y^*,t}$	$\varepsilon_{\pi^*,t}$	$\varepsilon_{q,t}$
1	Model 1	0.61	0.34	0.03	0.01	0.01
	Model 2	0.57	0.00	0.33	0.09	0.01
5	Model 1	0.55	0.35	0.06	0.02	0.02
	Model 2	0.18	0.02	0.66	0.14	0.00
10	Model 1	0.50	0.30	0.10	0.05	0.05
	Model 2	0.13	0.00	0.76	0.11	0.00
15	Model 1	0.47	0.29	0.12	0.05	0.07
	Model 2	0.13	0.00	0.77	0.10	0.00
20	Model 1	0.44	0.23	0.18	0.07	0.08
	Model 2	0.28	0.06	0.60	0.03	0.03
25	Model 1	0.42	0.16	0.22	0.10	0.10
	Model 2	0.09	0.00	0.82	0.09	0.00
30	Model 1	0.39	0.12	0.24	0.13	0.12
	Model 2	0.09	0.00	0.82	0.09	0.00
35	Model 1	0.37	0.08	0.25	0.16	0.14
	Model 2	0.09	0.00	0.82	0.09	0.00
40	Model 1	0.33	0.05	0.28	0.19	0.15
	Model 2	0.09	0.00	0.82	0.09	0.00

Source: Author calculation.

over the variation in itself, which is in line with the finding of Berkelmans (2005). Thus, it is critically important to analyse the dynamics of the money markets for the success of the CBRT's interest rate policy. Within this context, interactions between money and capital, derivatives and currency markets should be determined by the CBRT in an open economy framework. Furthermore, foreign factors should be considered in order to explain the variations in short-term interest rates as stressed by the forecast error variance decomposition results. Up to the 40th quarter, foreign output and price shocks account for approximately 50% of the variation in the overnight interbank rate in Model 1, while foreign dynamics have a major importance for the short-term interest rates since forecast error variance decompositions show that foreign shocks explain approximately 90% of the variation in the overnight interbank rate. These findings emphasise that economic integration of the Turkish economy with foreign economies has been deepened over the last decade. Accordingly, it can be asserted that macroeconomic policies targeting the convergence of the Turkish economy with the EU has been successful in this respect. Moreover, it was revealed that the CBRT has given importance to the dynamics of foreign economies in its monetary policy formulation when determining the policy rate. However, the limited effects of terms of trade shocks on the overnight interbank rate are in contrast to our implication about the increased integration level of the Turkish economy with foreign economies. We find that terms of trade shocks account for the 15% of the variation in overnight interbank rate from forecast error decompositions of Model 1. It can be interpreted that terms of trade shocks do not have any considerable impact on the dynamics of the overnight interbank rate as a result of Model 2.

Our forecast error variance decomposition results shown in Table 2 are supported by Berkelmans (2005) and Adolfson, Laséen, Lindé, & Villani, (2007b); we reveal that changes in the level of foreign economic activity may play a key role in comprehending the dynamics of short-term interest rates in money markets in Turkey. Accordingly, foreign output and price and terms of trade shocks should be considered by the CBRT when implementing monetary policy in the process of financial liberalization and economic integration, which have had a continuous path. On the other hand, consistent with the findings of Adolfson, Laséen, Lindé, & Villani, (2007b), technology shocks account for a maximum of 5% of the variation in the overnight interbank rate for the following quarters in contrast to the finding of Mertens (2010) who showed that technology shocks have a major role in the variations in interest rates. Nevertheless, the CBRT should determine its interest policy by taking into account the consequences of technology shocks.

5. Conclusions

In this study, we examined the effects of domestic and foreign macroeconomic factors on short-term interest rates in an open economy framework with the DSGE-VAR model for Turkey. Impulse response and forecast error variance decomposition results provide evidence of the fact that short-term interest rates may be seriously affected by the foreign shocks. According to the impulse response analysis, positive shocks in foreign output and prices lead to an increase in the short-term interest rate proxied by the overnight interbank rate. The positive effect of the shock in foreign output on the overnight interbank rate lasts for the following 40 quarters, while the positive effect of foreign price shock on the overnight interbank rate does not have as high an impact on the overnight interbank as foreign output. The coefficients of foreign price shocks derived from the impulse response analysis of both models are relatively smaller. Forecast error variance decomposition analysis indicates that foreign output and price shocks account for a major part of the forecast error variance of the overnight interbank rate in models 1 and 2. We also found that a positive terms of trade shock leads to a decrease in the overnight interbank rate and it can explain a maximum of 15% of the 40-step forecast error variance of the overnight interbank rate. Our findings imply that domestic economic activity is seriously under the influence of foreign shocks and thus the CBRT should consider foreign output, price and terms of trade shocks in monetary policy implementation. On the other hand, the positive effect of technology shocks on the overnight interbank rate is short-lived with an effect persisting in the following five quarters, and technology shocks explain a maximum of 5% of the 40-step forecast error variance of the overnight interbank rate. Accordingly, it can be interpreted that the influence of technology shocks on the short-term interest rate can be regarded as limited and temporary when compared with the effects of foreign shocks. Nevertheless, the CBRT should consider technology shocks as well as foreign output, price and terms of trade shocks to maintain price stability since developments in technology may lead to a reduction in costs for firms in the face of the current period of rapid technological progress.

Notes

1. When the relative PPP condition is assumed to hold, π_t is equal to $\pi_t = \Delta e_t + (1-\alpha)\Delta q_t + \pi_t^*$, where Δq_t is the change in terms of trade with respect to the previous period; π_t^* is a world inflation shock. It is assumed thatπ_t^* is an exogenous AR(1) process, $\pi_t^* = \rho_{\pi^*}\pi_{t-1}^* + \varepsilon_{\pi^*,t}$, where $\rho_{\pi^*}$is autoregressive coefficient and $\varepsilon_{\pi^*,t}$ denotes the innovations of the process.
2. See Galí and Monacelli (2005) and Mihailov, Rumler, & Scharler, (2011).

3. The specification of the IS Curve by Lubik and Schorfheide (2007) depends on the small open economy model with two sectors (household and firms) as summarised by Galí and Monacelli (2005).
4. For more details, see Lubik and Schorfheide (2007).
5. We calculate q_t as the relative price of exports in terms of imports. The terms of trade is placed in the IS curve equation as in first difference form (Δ) to reflect the changes in (relative) prices that affect CPI inflation.
6. Technological progress, foreign output and terms of trade are assumed to evolve according to univariate AR(1) processes: $z_t = \rho_z z_{t-1} + \varepsilon_{z,t}$, $y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_{y^*,t}$ and $\Delta q_t = \rho_q \Delta q_{t-1} + \varepsilon_{q,t}$, where, ρ_z, ρ_{y^*} and ρ_q are autoregressive coefficient and $\varepsilon_{z,t}$, $\varepsilon_{y^*,t}$ and $\varepsilon_{q,t}$ denote the innovations of the AR(1) processes.
7. x_t satisfies the relation $x_t = \Psi d_t + \sum_{l=1}^{k} \Pi_l (x_{t-l} - \Psi d_{t-l}) + \varepsilon_t$, $t = 1, ..., T$, where d_t is q dimensional and deterministic. The residuals ε_t are assumed to be i.i.d. Gaussian with zero mean and positive definite covariance matrix. Π_l is a matrix $(p \times p)$, while Ψ is $(p \times q)$, measuring the expected value of x_t. The elements of the vector x_t (d_t) are all elements of the vector y_t (x_t) in the measurement equation of the DSGE model (Warne, 2012).
8. For the identification of SVAR models, see Breitung, Brüggemann, and Lütkepohl (2007).
9. For the details of the conditional variance decompositions of the DSGE model function, see Warne (2012).
10. The real GDP, consumer price inflation, overnight interbank rate and nominal exchange rate series are obtained from the OECD database; export and import price indices are extracted from the database of the CBRT.
11. For the details of the UR test, see Saikkonen and Lütkepohl (2003) and Lütkepohl (2007).
12. Prior distribution of model parameters identical and priors for the parameters of the model were determined to consider the fact that Turkey is a natural resource importing country. Therefore, domestic business cycle fluctuations are likely to have a major international relative price component in Turkey. Initial values, prior distribution of model parameters and parameter estimates can be provided upon request.
13. Estimation procedure requires the vector B_t, containing the variables used in the model to be modified as: $B_t = (4r_t, 4\pi_t, y_t, \Delta e_t)'$. For more information on the technical details of the estimation procedure, see Warne (2012).

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