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Revisiting Monetary Policy Effectiveness in Turkey Using a FAVAR Model

Summary: This study aims to perform a comparative analysis of the effectiveness of pass-through of policy rates in Turkey. We explore monetary transmission with different choices of instruments, i.e., the Turkish Lira Reference Interest Rate (TRLIBOR rate), BIST overnight rate, and Divisia money, and under different policy regimes, i.e., inflation targeting and new monetary policy regimes. We estimate a two-stage FAVAR model to use all of the available information set and obtain direct responses of disaggregated/sectorial series for the period 2005:12-2018:4. We extend the model setting proposed by Bernanke, Boivin, and Eliasz (2005) by considering the multiple-policy environment in Turkey. Our findings promote arguments that regard policy rate as a poor indicator of the policy stance in Turkey.

Keywords: Monetary transmission, FAVAR model, Policy rate, Divisia index, Turkey.

JEL: E51, E52, E58.

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This study investigates the extent to which the policy rate is de-potentiated in policy-making in Turkey. That is, we explore the validity of the arguments that defend the limited or blurred pass-through of the central bank policy rate during monetary transmission. For this aim, we use the factor augmented VAR (FAVAR) model developed by Ben S. Bernanke, Jean Boivin, and Piotr Eliasz (2005). We prefer to implement this model as it largely solves drawbacks of the small-scale VAR models; enables us to use all informative series; and allows us to obtain direct responses of all disaggregated series in the data set and incorporate the multiple policy environment into the model.

We estimate the model assuming that the policy rate represents Turkey's monetary policy stance. Then, we extend the model by drawing "monetary policy factors" to capture the main components of the policy agenda set by the central bank, not fully provided by the policy rate. We also construct and analyze Divisia money in monetary transmission to visualize the relative performance of the policy rates against a hypothetical but theoretically convincing money supply definition. Further, we analyze the effectiveness of official rates relative to effective rates under a more consolidated period, i.e., a new monetary policy episode that witnesses a vigorous use of multiple policy instruments.

The main contribution of the study to the literature is three-fold: first, we perform a comprehensive analysis of the effectiveness of pass-through of policy rates in the stance of the monetary policy of Turkey using disaggregated data, with a comparison of alternative instruments and under different regimes. Second, we revisit the model setting proposed by Bernanke, Boivin, and Eliasz (2005) and Serdar Varlık and Hakan Berument (2017) by modeling the multiple policy environment to mimic the policy stance in Turkey. Finally, we construct a hypothetical instrument (Divisia money) for Turkey and compare this instrument with the short-term interest rates in our model.

The paper is organized as follows: In Section 1, we briefly review the monetary policy stance of the Central Bank of the Republic of Turkey (CBRT). We introduce models in Section 2, and Section 3 contains the estimation procedure and implementation of model settings. In Section 4, we make a primary analysis before the estimation. Sections 5 and 6 provide discussions on results and robustness controls, respectively. Section 7 concludes our analysis.

1. Monetary Policy Stance of the CBRT: A Brief Review

In this section, we give a brief account of the monetary policy stance of the CBRT and the effectiveness of policy instruments/choices set by the bank. This review is made for the period 2005-2018 to match the empirical analysis. Monetary policy-making in Turkey can be defined chronologically under two periods: the conventional (interest rate-oriented) inflation targeting regime period from the end of 2005 through May 2010 and, thereafter, the unconventional policy period (backed by an asymmetric interest rate corridor system).

Under the explicit inflation targeting policy framework, the CBRT employed the overnight borrowing rate as the official policy rate and benefited from short-term interest rates (e.g., late liquidity windows on the overnight lending and borrowing rates, foreign exchange buying/selling auctions and interventions, required reserve ratios, and discount rates) in the provision of the price stability objective (Varlık and Berument 2017). Also, to alleviate the contagion effect of the global financial crisis in late 2008, the central bank called upon other tools than short-term interest rates. Among others, the CBRT increased foreign currency transaction limits of banks and foreign currency required reserve ratios improved the export rediscount credit conditions, and reduced the overnight lending rates (Central Bank of the Republic of Turkey 2021a)[1].

As capital inflows turned to more emerging economies in late 2009, the CBRT took steps to manage the liquidity glut, prevent potential risks to the current account deficit, and consolidate financial stability (Hakan Kara 2013). The bank designed a policy mix that took the policy rate with alternative instruments as liquidity management and reserve requirements in 2010 to enhance policy effectiveness. By doing so, the bank determined financial stability as a secondary objective besides price stability,

[1] **Central Bank of the Republic of Turkey.** 2021a. Monetary Policy Texts. https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Publications/Monetary+Policy+Texts/Monetary+Policy+Texts/ (accessed August 10, 2021).

and used a number of alternative instruments to contain macro-financial risks, prevent excessive credit growth, and stabilize real exchange rates.

In consolidation of a multi-objective policy stance, the CBRT introduced an asymmetric interest rate corridor system and enhanced its tools in late 2010. The bank changed the policy rate to the one-week repo rate from the overnight rate this year. This period is also designated as the unconventional or new monetary policy episode. Central banks usually operate under a conventional corridor mechanism by using a single policy rate within a corridor to conduct monetary policy (Mahir Binici, Kara, and Pınar Özlü 2016). Thus, the policy rate is used as the core of the policy stance in monetary transmission and determined under a narrow band (Lawrence J. Christiano, Martin Eichenbaum, and Charles L. Evans 1999; Sanchita Mukherjee and Rina Bhattacharya 2011; Philip Arestis, Fernando F. Filho, and Fábio H. B. Terra 2018). Being different from the conventional corridor system, the CBRT allowed systematically efficient rates to diverge from policy rates and benefited from this divergence as a policy instrument. Also, unlike the typical conventional corridor system, the CBRT changed the upper and lower bounds of the corridor asymmetrically, i.e., at different directions and rates (Binici, Kara, and Özlü 2016). Note that the borrowing rate is taken as the lower bound while the lending rate (or marginal funding rate) stands for the upper bound of the corridor. In this way, changes in the width of the corridor, i.e., the distance between overnight lending and borrowing rates to banks, were used as another instrument besides the policy rate.

Throughout the unconventional monetary policy period, the CBRT still announced its loyalty to the policy rate in its reports. By using policy rate changes, the bank declared to aim at preventing the deterioration in the inflation outlook, operate the liquidity conditions and expectations, and counteract external disturbances (CBRT 2021b)[2]. However, alternative policy instruments were vigorously employed to manage different state variables under a multi-objective and multi-instrument policy framework (Ahmet F. Aysan, Salih Fendoğlu, and Mustafa Kılınç 2014; A. Erinç Yeldan and Burcu Ünüvar 2016; Binici, Kara, and Özlü 2018). Under this multi-objective and multi-instrument policy framework, the monetary policy is evaluated as noisy and opaque (Yeldan and Ünüvar 2016) and the policy rate announcements are regarded as uninformative about the conduct of monetary policy (Refet S. Gürkaynak et al. 2015; Abdurrahman N. Çatık and Coşkun Akdeniz 2019). It is also stated that the divergence of the efficient rates from the policy rates by the central bank resulted in an indeterminate state in policy-making (Hande Küçük et al. 2016). Further, the pricing of loans and deposits is found to be driven by the effective rates, i.e., CBRT average funding rate and interbank repo rate, under the multiple policy environment.

Observing complexities in the monetary policy stance and uncertainties on the effectiveness of the policy rate, the CBRT started to simplify its tools in 2016. The process of simplifying monetary policy was initiated by approaching the policy rate to the funding rate and narrowing the interest rate corridor by reducing the upper bound

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[2] **Central Bank of the Republic of Turkey.** 2021b. Annual Reports. https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Publications/Reports/Annual+Reports/ (accessed August 10, 2021).

of the corridor (the CBRT overnight lending rate). However, the bank could not complete this simplifying process until the beginning of 2018.

2. Model

2.1 Baseline Model

Let Y_t and X_t be two $M \times 1$ and $N \times 1$ vectors of observable economic variables, respectively, with a time index t, $t = 1,2, \dots, T$; and it can be $N \gg T$ or $N \ll T$. Following the monetary VAR literature, Y_t stands for pervasive forces that characterize the dynamics of the economy, i.e., a vector that contains a policy variable and several observable indicators of prices and real activity (Bernanke, Boivin, and Eliasz 2005). The term X_t stands for the available number of informative series relevant to the dynamics of the economy and used by central banks to capture additional information which is not fully provided by Y_t. To capture this additional information, Bernanke, Boivin, and Eliasz (2005) propose a $K \times 1$ vector of unobservable factors, F_t, and consider the policy rate as the only observable indicator, Y_t, in their setting. These unobservable factors are used to measure "theoretically motivated concepts such as economic activity, price pressures, or credit conditions that cannot easily be represented by one or two series but rather are reflected in a wide range of economic variables" (Bernanke, Boivin, and Eliasz 2005, p. 392) with $N \gg M + K$. Therefore, the dynamics of Y_t and F_t can be jointly expressed in a state-space representation using the following transition equation:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \nu_t, \quad E(\nu_t{}'\nu_t) = \mathrm{Q}, \tag{1}$$

where $\phi(L)$ is a lag polynomial of finite order d, ν_t is an error term with zero mean, and covariance Q, $\nu_t \sim i.i.d. N(0, Q)$. Equation (1) can be reduced to a standard VAR model with only Y_t if terms of $\phi(L)$ are equal to zero. As F_t contains additional information, the VAR model in Y_t will probably result in biased estimates of coefficients and impulse responses. As the factors, F_t, are not observable, one cannot estimate Equation (1) directly. To capture the "information content" of unobserved factors, one can relate available informational time series, X_t, to F_t and observed time series, Y_t, using the observation equation below:

$$X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t, \qquad E(e_t{}'e_t) = \mathrm{R}\,, \tag{2}$$

where Λ^f is an $N \times K$ matrix of factor loadings, Λ^y is a $N \times M$ matrix, and e_t is a $N \times M$ vector of error terms with zero means. The error terms in Equations (1) and (2) are assumed to be independent and the error terms in Equation (2) are assumed to be diagonal. Note that the observation equation implies a static formation of the dynamic factor model so that X_t depends only on the current value of F_t.

2.2 Extended Model

In the extended model, we revise the model defined in Equations (1) and (2) by partitioning the large data set, X_t, off two sub-groups, i.e., ${X_t}^1$ and ${X_t}^2$, where ${X_t}^i$ is a

$W_i \times 1$ vector such that $\sum_i W_i = W$. ${X_t}^2$ corresponds to the set of policy instruments used by the monetary authority, while ${X_t}^1$stands for observable economic variables. We preserve the assumption on Y_t as a $M \times 1$ vector that contains only a policy variable. Following Francesco Belviso and Fabio Milani (2006) and Varlık and Berument (2017), we assume that ${X_t}^i$ is merely explained by the underlying factor, ${F_t}^i$, with a $Z_i \times 1$ vector such that $\sum_i Z_i = Z$ and $Z_i < W_i$, $i = 1, 2$. Thus we obtain unobserved "monetary policy factors", ${F_t}^i$, drawn from ${X_t}^2$ to capture the policy agenda set by the monetary authority which is not fully provided by the policy rate. We include monetary policy factors along with the (observable) policy instrument under the extended model to better mimic the conduct of policy that calls vigorously on multiple policy instruments, and track the transmission mechanism more realistically compared to one instrument case. As the policy instruments are used simultaneously, we can control the policy stance by using monetary policy factors while analyzing a shock to a single policy instrument. In the matrix form, we have:

$$\begin{bmatrix} {X_t}^1 \\ R_t \\ {X_t}^2 \end{bmatrix} = \begin{bmatrix} \Lambda^{f1} & 0 & 0 \\ 0 & \Lambda^r & 0 \\ 0 & 0 & \Lambda^{f2} \end{bmatrix} . \begin{bmatrix} {F_t}^1 \\ R_t \\ {F_t}^2 \end{bmatrix} + \varsigma_t.$$

This implies the observation equation as follows

$$X_t = \Lambda^{f1} {F_t}^1 + \Lambda^r R_t + \Lambda^{f2} {F_t}^2 + \varsigma_t, E({\varsigma_t}' \varsigma_t) = \mathrm{P}, \varsigma_t \sim i.i.d.N(0, \mathrm{P}), \quad (3)$$

and transition equation as follows:

$$\begin{bmatrix} {F_t}^1 \\ R_t \\ {F_t}^2 \end{bmatrix} = \varphi(L) \begin{bmatrix} {F_{t-1}}^1 \\ R_{t-1} \\ {F_{t-1}}^2 \end{bmatrix} + \chi_t, E({\chi_t}' \chi_t) = \Upsilon, \quad (4)$$

where $\varphi(L)$ is a lag polynomial of finite order d, $\chi_t \sim i.i.d.N(0, \Upsilon)$ and the error term χ_t requires $E\left(\chi_t \middle| {F_t}^1, R_t, {F_t}^2\right) = 0$.

The restriction that ${X_t}^i$ is merely explained by the underlying factor, ${F_t}^i$, implies no contemporaneous covariance across different subgroups, conditional on the factors, i.e., $E\left({X_{wt}}^1, {X_{zt}}^2 \middle| {F_t}^1\right) = 0$ for all $w, z = 1,2 \ldots, N$ with $w \neq z$. However, explaining the macroeconomic series completely by corresponding factors may not be empirically so consistent if there exist some contemporaneous links among series.

In our case, it is highly possible to get significant impacts of the utilization of monetary policy tools on market interest rates or asset prices. In extracting factors from subsets of X_t, thus, we re-calculate rotated factors by including the fast-moving monetary policy factors in addition to the observed variables. This enables us to remove the direct dependence of $\hat{C}\left({F_t}^1, {F_t}^2, Y_t\right)$ on ${F_t}^2$ and Y_t providing theoretical consolidation of orthogonal factors both within and across subsets of X_t, i.e., $E\left({X_{wt}}^1, {X_{zt}}^2 \middle| {F_t}^1\right) = 0$. It also prevents over-estimated responses of time series to policy shocks under consideration.

3. Estimation and Implementation of Model Settings

In the estimation of the model, we follow the non-parametric two-stage principal components (PC) approach instead of the fully-parametric one-stage maximum likelihood approach. The former is computationally simple, requires few precise distributional assumptions in the observation Equation (2), allows for small cross-correlations in the error terms, e_t, and provides estimated factors that carry more information due to its low level of structural assumptions (Bernanke, Boivin, and Eliasz 2005). These features make this approach advantageous compared to the Bayesian joint estimation by maximum likelihood approach. However, the previous literature obtained mostly larger confidence intervals on the impulse response functions under the two-stage approach (see Kemal Bağzıbağlı 2014). The existence of rotated factors in the second stage may imply a "generated regressors" problem. Firstly, as our N is large enough compared to T, using PC estimators can avoid this problem. Also, we implement a recursive-design residual bootstrap algorithm to obtain more consistent confidence intervals.

Note that Equations (1) and (2) are estimated separately. The first stage consists of estimating pervasive forces in observation Equation (2) before estimating the transition Equation (1). The space covered by factors is obtained using the first $M + K$ principal components of X_t and shown by $\hat{C}(F_t, Y_t)$. The assumption is that F_t and Y_t together capture the common variations of all the variables in X_t (Rita Soares 2013). As stated by James H. Stock and Mark W. Watson (2002), if N is large relative to T and the number of PC is sufficiently large to capture the true number of factors, then PC consistently recover the space spanned by both F_t and Y_t. After estimating the rotated factors, $\hat{F}_t$, Equation (1) is estimated with $\hat{F}_t$ and Y_t in a standard VAR fashion in the second stage.

Therefore, the FAVAR model requires us to identify restrictions on the factor loadings, the VAR setting, and contemporaneous time restrictions. First, assume that coefficient matrix $\hat{\Lambda}^f$ and factors $\hat{F}_t$ together are solutions to the model estimation given by Equations (1) and (2). Let $\tilde{\Lambda}^f = \hat{\Lambda}^f L$ and $\tilde{F}_t = \hat{F}_t L$ also satisfy the estimation, where L is a $K \times K$ nonsingular matrix. Bernanke, Boivin, and Eliasz (2005) impose a normalization by replacing $\hat{F}_t$ with $\tilde{F}_t$ as it does not change the information content of the estimated factors. The identification of factors can be provided by imposing factors $F^{i'} F^i / T = I$ or imposing factor loadings $\Lambda_i^{f'} \Lambda_i^f / N = I$ for the first k number of factors $i = 1, 2, \dots, k$.

The identification of the VAR setting is determined under the recursive scheme defined by Bernanke, Boivin, and Eliasz (2005) and Stock and Watson (2005). This implies a Cholesky decomposition of the reduced form variance-covariance matrix of residuals, and $E(\nu_t{}' \nu_t) = \mathrm{Q}$ in Equation (1). Thus, the first k numbers of rotated factors will respond to an unanticipated policy shock with a lag in the transition equation. The contemporaneous feedback in the reverse direction is also allowed (Carlo Favero 2001). By using an orthogonal invertible matrix A (see Christopher A. Sims 1980) with the dimension $[(K + M) \times (K + M)]$, the structural FAVAR model is traced from the reduced form. Hence, we define the relationship between the (unobservable) structural disturbances (ψ_t) and (observed) VAR residual (v_t) as $\psi_t = Av_t$ with $E(\psi_t\psi_t{}') = I$ and $E(v_t v_t{}') = AA'$.

We use time restrictions to avoid potential contemporaneous links between informative series and the selected policy instrument. We trace, accordingly, a "Slow-R-Fast" scheme for time restrictions under which "slow-moving" variables (e.g., output, wages, and prices) are predetermined before the current period while monetary policy innovations (R) influence the "slow-moving" series within the same period. Further, "fast-moving" series (e.g., asset prices and variables of expectations) are assumed to react contemporaneously to all innovations.

In the empirical implementation of the model, we cover the first stage of the estimation in four steps. First, we divide X_t into slow- and fast-moving series following the "Slow-R-Fast" scheme (see Bernanke, Boivin, and Eliasz 2005; Boivin, Marc P. Giannoni, and Ilian Mihov 2009; Soares 2013), and following Stock and Watson (2016) we order the series from slowest to fastest in our data set, X_t. Next, we estimate F_t from X_t, and then we apply PC to the slow-moving series to obtain the matrix of slow-moving factors ($F_{slow,t}$). Finally, we estimate the following regression equation by equation for each factor:

$$F_t = \alpha + D \times (F_{slow,t}) + B \times Y_t + \varepsilon_t, \tag{5}$$

where Y_t shows the policy instrument being the observable variable. Thus, for the first k number of PC, it becomes:

$$\begin{gathered} F_t^1 = \alpha_1 + \beta_1 \times \left(F_{slow,t}^1\right) + \cdots + \beta_K\left(F_{slow,t}^K\right) + \gamma_1 Y_t + u_t, \\ F_t^2 = \alpha_2 + \beta_2 \times \left(F_{slow,t}^1\right) + \cdots + \beta_K\left(F_{slow,t}^K\right) + \gamma_2 Y_t + v_t, \\ \vdots \\ F_t^K = \alpha_K + \beta_K \times \left(F_{slow,t}^1\right) + \cdots + \beta_K\left(F_{slow,t}^K\right) + \gamma_K Y_t + z_t. \end{gathered}$$

To avoid any potential contemporaneous correlation between fast-moving series ($F_{fast,t}$) and the selected policy instrument, we estimate the rotated factors ($F_{new,t}$) using the equation $F_{new,t} = F_t - B \times Y_t$:

$$\begin{gathered} F_{new,t}^1 = F_t^1 - \gamma_1 Y_t, \\ F_{new,t}^2 = F_t^2 - \gamma_2 Y_t, \\ \vdots \\ F_{new,t}^K = F_t^K - \gamma_K Y_t. \end{gathered}$$

In this way, we remove the direct dependence of $\hat{C}(F_t, Y_t)$ on Y_t. In the second stage, we estimate a VAR setting in $F_{new,t}$ and Y_t.

In the implementation of the extended model, we revise the baseline model by considering the policy rate and the monetary policy factors together to stand for the observable variables, Y_t. For the fast-moving monetary policy instruments included in X_t^2, we do not assume any ordering while we follow the "slow-R-fast" scheme for X_t^1. Then, we estimate common factors F_t^1 using X_t^1 and "monetary policy factors" using X_t^2. Next, we obtain the matrix of slow-moving factors $\left(F_{slow,t}^1\right)$ from X_t^1. Finally, we regress $F_t = \alpha + D \times \left(F_{slow,t}^1\right) + C \times (F_t^2) + B \times Y_t + \varepsilon_t$ equation by equation for each factor. We estimate the rotated factor ($F_{new,t}$) from the linear equation: $F_{new,t} = F_t - C \times F_t^2 - B \times Y_t$.

In the second stage, we estimate a VAR in $F_{new,t}$ and Y_t. We obtain significant causality from monetary policy factors to selected policy rates, but the reverse is not the case. We assume, accordingly, feedback from the monetary policy instruments to the policy rate and slow-moving macroeconomic series in our model.

4. Primary Analysis

In this section, we introduce the data set and explain how we determine the number of factors and lag length before moving into model estimation under different specifications.

4.1 Data Set

The data set consists of a balanced panel of 113 disaggregated macroeconomic series for the period spanning 2005:12-2018:4. A detailed description of the data set is provided in the Appendix. The choice of starting date is essentially made given that the monetary authority in Turkey announced it would pursue explicit inflation targeting policy setting at the beginning of 2006. By extension, the Turkish economy gradually succeeded in a relatively low inflationary environment in the mid-2000s. Further, all the definitions of monetary aggregates were revised at the end of 2005 to conform to international standards in the monetary sector, so that Divisia-type monetary aggregates are constructed starting from this date.

Following the literature on factor models (Stock and Watson 2002, 2005; Bernanke, Boivin, and Eliasz 2005; Karim Barhoumi, Olivier Darn, and Laurent Ferrara 2010; Soares 2013; Varlık and Berument 2017) and with the availability of the Turkish data, we collected a wide range of sectoral and disaggregated series. Following the policy agenda set by the CBRT, we include a variety of instruments to obtain the "monetary policy factors" to be used in the extended model. As the Turkish economy is considered among the most fragile emerging markets with its high foreign indebtedness and its vulnerabilities to external forces, we included a set of foreign series to track the external impacts via an external factor. We also controlled for a certain number of dummies including a crisis dummy starting from 2008:9 and a financial stability dummy starting from 2011:1 based on the CBRT's objectives toward the provision of financial stability. The results are robust to the use of dummies.

We organize the data as follows. First, to remove seasonal patterns of the series, we rely on the X-12-ARIMA approach with multiplicative decomposition for non-negative series and with additive decomposition for the remaining series. Second, we transform the series by taking the logarithm, first difference, or first difference of logarithm to obtain approximate stationarity in the data set. The interest rate series are expressed in terms of the first difference. We take the first difference of the policy rate (see Logan Kelly, William A. Barnett, and John Keating 2011) instead of using the series in level (see Sims 1992) which induces stationarity and leads to narrower confidence bands of the response functions. Third, we correct the transformed series for the outliers. For this purpose, we define outliers as the observations of transformed series with median deviations (in absolute terms) larger than six times the interquartile range and correct for the outliers by replacing them with the median value of the preceding five observations (see Stock and Watson 2005; Jörg Breitung and Sandra Eickmeier 2011). Finally, we normalize all the series used in the computation of factors to have zero-mean and unit variance.

4.2 Factor Determination

In determining the number of potentially useful static factors, the literature essentially benefits from "a combination of the a priori knowledge, visual inspection of a scree plot, and the use of information criteria and other statistical measures" (Stock and Watson 2016, p. 435). In Table 1 we report some of the literature on monetary FAVAR models. We observe first that except for Juan S. Holguín and Jorge M. Uribe (2020), the literature sticks largely to 2-stage PC estimation due to Bernanke, Boivin, and Eliasz (2005). It also arises that the literature is essentially based on Jushan Bai and Serena Ng (2002) with different panels of information criteria ($IC_p(k)$ and/or $PC_p(k)$) to derive the number of static factors, while a few of them use Bai and Ng (2007) to obtain the dynamic factors. It is only Holguín and Uribe (2020) that use the BIC criteria. Some of the studies also benefit from the scree plot analysis. Note also that there are other but less employed approaches in determining the number of factors, such as those of Alexei Onatski (2010) and Seung C. Ahn and Alex R. Horenstein (2013).

Table 1 Studies on the Monetary FAVAR Models with Two-Stage Estimation

Study	Estimation method	Number of factors	Country and the data
Bernanke, Boivin, and Eliasz (2005)	2-stage PC	3-static factors (from 120 series) Bai and Ng (2002)	US 1959:M1-2001:M8
Rangan Gupta, Marius Jurgilas, and Alain Kabundi (2010)	2-stage PC	2- dynamic factors (from 246 series) Bai and Ng (2007)	South Africa 1980:M1-2006:M4
Konstantis Benkovskis et al. (2011)	2-stage PC	3- dynamic factors for Poland, 4 for the Czech Republic and Hungary (from 200 series) Bai and Ng (2002)	Poland, Czech Republic, and Hungary 1999:Q2-2010:Q3
Soares (2013)	2-stage PC	7-static factors (explain 59% of 150 series) Bai and Ng (2002), scree plots	16-country EA 1999:M1-2009:M3
John G. Fernald, Mark M. Spiegel, and Eric T. Swanson (2014)	2-stage PC	2-factors (explains 28% of 35 series) No information on how they set the number of factors	China 2000:M1-2013:M9
Varlık and Berument (2017)	2-stage PC	5-factors (explains 99% of 59 series) Bai and Ng (2002)	Turkey 2001:M12-2016:M4
Holguín and Uribe (2020)	2-stage PC with time restrictions	5-factors (explains 42% of 99 series) Bai and Ng (2002), scree plots, BIC	U.S. 2001:M1-2016:M4

Source: Author's compilation.

Following the literature, we apply a panel of information criteria, $IC_p(k)$, and $PC_p(k)$, due to Bai and Ng (2002) and the usual BIC and AIC information criteria as the further test-statistics. To better observe the marginal contributions of first k factors to R^2 of the large data set, we also used the scree plot analysis. Finally, we estimate the model with different numbers of factors to control whether altering the number of factors changes the results significantly.

Bai and Ng (2002) define a class of criteria $IC(k) = ln\left(V\left(k, \hat{F}_k\right)\right) + kg(N, T)$ in consistently estimating the true number of factors (r) with estimated factors (k). The term $V\left(k, \hat{F}_k\right)$ stands for the sum of squared residuals divided by NT $\left(\text{i.e., } V\left(k, \hat{F}_k\right) = \min(NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(X_{it} - \lambda_i^{k'} \hat{F}_{kt}\right)^2\right)$ and corresponds to the goodness-of-fit side. The term $g(N, T)$ is a penalty function for overfitting which increases with both N and T. We also include the usual AIC_3 and BIC_3 that consider both N and T dimensions in estimation alongside the set of criteria $(PC_{p1}, PC_{p2}, PC_{p3}, IC_{p1}, IC_{p2}, IC_{p3})$ proposed by Bai and Ng (2002).

Assuming $\hat{\sigma}^2$ as a consistent estimate of $(NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} E(e_t)^2$ we can define the criteria as follows:

$$
\begin{aligned}
PC_{p1} &= V\left(k, \hat{F}_k\right) + k\hat{\sigma}^2 \left(\frac{N+T}{NT}\right) \ln\left(\frac{NT}{N+T}\right), \\
PC_{p2} &= V\left(k, \hat{F}_k\right) + k\hat{\sigma}^2 \left(\frac{N+T}{NT}\right) \ln C_{NT}^2, \\
PC_{p3} &= V\left(k, \hat{F}_k\right) + k\hat{\sigma}^2 \left(\frac{\ln C_{NT}^2}{C_{NT}^2}\right), \\
IC_{p1} &= ln\left(V\left(k, \hat{F}_k\right)\right) + k\left(\frac{N+T}{NT}\right) \ln\left(\frac{NT}{N+T}\right), \\
IC_{p2} &= ln\left(V\left(k, \hat{F}_k\right)\right) + k\left(\frac{N+T}{NT}\right) \ln C_{NT}^2, \\
IC_{p3} &= ln\left(V\left(k, \hat{F}_k\right)\right) + k\left(\frac{\ln C_{NT}^2}{C_{NT}^2}\right), \\
AIC_3 &= V\left(k, \hat{F}_k\right) + k\hat{\sigma}^2 \left(2\frac{N+T-k}{NT}\right), \\
BIC_3 &= V\left(k, \hat{F}_k\right) + k\hat{\sigma}^2 \left(2\frac{(N+T-k)\ln(NT)}{NT}\right),
\end{aligned}
$$

where $C_{NT}^2 = min\{N, T\}$ is used to set the average rate of convergence between k and r.

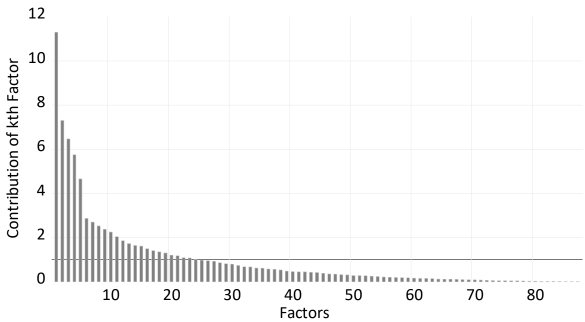
The panel of information criteria reveals that the estimated number of factors is sensitive to the choice of the maximum number of factors only in PC_{p3}, IC_{p3} and BIC_3. For these criteria, when the optimal number of static factors is controlled for $k = 3, 4, \ldots, 10$, increasing k results in the number of optimal static factors rising proportionally (see Table 2). Applying PC_{p1}, PC_{p2}, IC_{p1}, and IC_{p2} criteria, however, gives $k = 5$ even if the maximum number of factors is increased to 10. Further, AIC_3 suggests the number of factors as two while under BIC_3 the number of factors is sensitive to the choice of the maximum number of factors.

The scree plot analysis in Figure 1 displays a bar graph of the marginal contributions of each factor against the total number of factors. We observe a kink point in the 5th factor and the first five factors explain 42% of the total variance in X_t. Including the 6th factor contributes only 3% to R^2. Also, the marginal gain from including 10 factors instead of 5 factors is around 13%. Finally, we find no evidence of improvement in response functions in significance as we increase the number of factors (see Section 6.2). Accordingly, we determine the number of factors as five. We determine one external factor extracted separately from a group of foreign variables to encompass the potential external impacts on the Turkish economy and consider it as an exogenous variable to the system. The first factor explains about 47% of the total variance in foreign variables.

Table 2 Panel of Criteria in Determining the Number of Factors

Cr.	$K_{max}=3$	$K_{max}=4$	$K_{max}=5$	$K_{max}=6$	$K_{max}=7$	$K_{max}=8$	$K_{max}=9$	$K_{max}=10$
PC_{p1}	3	4	5	5	5	5	5	5
PC_{p2}	3	4	5	5	5	5	5	5
PC_{p3}	3	4	5	6	7	8	9	10
IC_{p1}	3	4	5	5	5	5	5	5
IC_{p2}	3	4	5	5	5	5	5	5
IC_{p3}	3	4	5	6	7	8	9	10
AIC_3	1	1	1	1	1	2	2	2
BIC_3	3	4	5	6	7	8	9	10

Source: Author's calculation.



Notes: The value of one, shown with the horizontal line, is equal to the average of the calculated eigenvalues.

Source: Author's calculations.

Figure 1 Scree Plots for Contribution of Factors

The FAVAR model by formation lacks any structural identification scheme in relating each factor to some group of macroeconomic series. Also, estimated static factors stand for the space spanned by factors instead of the factors themselves (Soares 2013). Thus, the interpretation of the factors can be grounded on non-parametric analyses. In revealing potential matching across our rotated factors and macroeconomic series, we used Pearson's correlation coefficients among the factors and some of the macroeconomic series, based on the permutation test with the statistical significance level at 1%. We report the highest correlation coefficients in Table A2 in the Appendix. We refrain from giving a specific name for each of the factors. Still, we observe that factor 1 co-moves largely with the dynamics of the exchange rate and foreign debt markets. Also, Figure A1 in the Appendix denotes the fitted value from a regression of basket rate changes on factor 1 along with the series of basket rates. The single equation gives a relatively high explanatory power for this common factor ($R^2 = 0.68$). Other factors were also found to feature similar estimation results for selected macroeconomic series. Factor 2 correlates largely to the dynamics of credit conditions, while the third and fourth factors essentially co-move with real activity. The fifth factor seems to capture consumer confidence.

4.3 Determination of Lag Lengths and Impulse Response Functions

To solve the trade-off of improved fit by including more lags against the over-fitting problem and reduction in the degrees of freedom, we apply standard test statistics of LLR, AIC, SC, and HQ.

In the FAVAR literature there are no specific preferred information criteria to determine the lag length (Bağzıbağlı 2014). In Bernanke, Boivin, and Eliasz (2005), the number of lags is chosen as thirteen in an ad hoc manner to capture the main dynamics of the economy. In our study, however, to determine the lag length used in our model, we followed Bağzıbağlı (2014), and using our estimated five factors, one external factor and the selected policy rate, we estimated the baseline FAVAR model with seven variables ($n = 7$). Based on the standard test statistics of LLR, AIC, SC, and HQ, the lag order turns out to be two in the baseline model. Finally, we control whether the selected lag length results in any problem of autocorrelation, non-normality, and instability of residuals in the model using autocorrelation LM test, square root of correlation (Doornik-Hendry) test statistics, and AR roots tables, respectively, and found estimated residuals to be well behaved. The residuals of selected policy rates featuring non-normality are the only exception, but the related series are found to be stable.

The FAVAR model enables us to obtain the impulse response functions of all the variables by manipulating the weights (factor loadings) with which the series are reconstructed from the estimated factors and observable series. The impulse response functions of the estimated factors and the observable variables are obtained as follows:

$$\begin{bmatrix} \hat{F}_t \\ Y_t \end{bmatrix} = \widehat{\Psi}(L)\varepsilon_t,$$

where $\widehat{\Psi}(L) = \left(\hat{\psi}_t\right)^{-1} = \widehat{\Psi}_0 - \widehat{\Psi}_1 L - \cdots - \widehat{\Psi}_h L^h$ is a matrix of polynomials in finite order h, in the lag of L and $\widehat{\Psi}_i$ ($i = 0,1,\ldots,h$) is the coefficient matrix. Using the estimated factor loadings in the observation equation, i.e., $\hat{X}_t = \widehat{\Lambda}^f \hat{F}_t + \widehat{\Lambda}^y Y_t$, the impulse response function of any variable included in the data set can be obtained as follows:

$$X_{j,t}^{IRF} = [\widehat{\Lambda}^f \quad \widehat{\Lambda}^y] \begin{bmatrix} \hat{F}_t \\ Y_t \end{bmatrix} = [\widehat{\Lambda}^f \quad \widehat{\Lambda}^y] \widehat{\Psi}(L)\varepsilon_t.$$

5. Results

In this section, we estimate (i) the basic model ($Y_t = R_t$); (ii) the extended model ($Y_t = R_t$, Policy Factors); (iii) the baseline model replacing the policy rate with TRLIBOR rate ($Y_t =$ TRLIBOR Rate); and (iv) the baseline model replacing the policy rate with Divisia M2 ($Y_t =$ Divisia M2). The comparison of impulse response functions under alternative policy instruments and models is made to assess whether the policy rate is a complete indicator of the monetary policy stance and whether alternative instruments improve the transmission of the monetary policy to the economic indicators.

5.1 Baseline Model

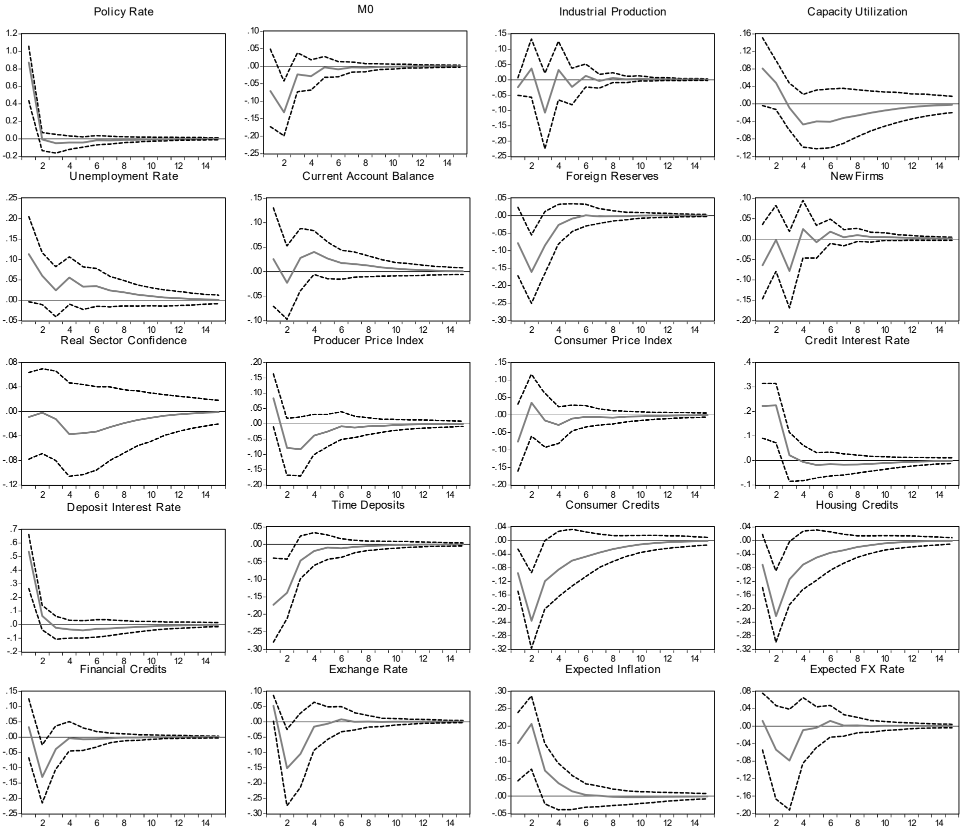
We estimated impulse response functions of selected variables to one-standard-deviation contractionary shock to the policy rate under the baseline model (Figure 2). We decided to select the response functions of 20 variables to reflect different aspects of the Turkish economy (real activity, exchange market, prices, credit market, expectations, and market rates). Impulse response functions are in the form of standard errors and statistical significances are evaluated with 90% confidence bands (dashed lines) obtained using bootstrapping with 1000 iterations (see the Appendix for the details of the bootstrapping algorithm).

The baseline model replicates Bernanke, Boivin, and Eliasz (2005). Thus, we considered policy rate as the only observable variable. The policy rate corresponds to the lending rates announced periodically in the policy statements of CBRT and is assumed to summarize the central bank's policy set (Binici, Kara, and Özlü 2018). More specifically, the overnight lending rate and one-week repo rate arise as two lending rates at which the central bank meets the liquidity needs of the banking system. We use the lending rate until 2010:5 and the weekly repo rate thereafter to set the policy rate. Note that the weekly repo rate changes more passively and with a delay under the unconventional policy framework of the CBRT compared to the average funding cost interest rate. It can be argued for the latter to better capture the funding decisions of the participants as it arises as a combination of the amounts of quotations and auctions along with their corresponding costs. Still, as the CBRT clamorously announces its loyalty to the policy rate (CBRT 2015, 2019) we consider the repo rate to obtain the policy rate series.

Following a contractionary monetary policy shock to the policy rate, we observe a largely negative impact on economic activity, i.e., a fall in the employment rate, industrial production index, capacity utilization rate, and the number of new firms. Even though the response of the industrial production index is mostly negative, the resulting significance is quite low. This result is consistent with recent findings (e.g., Çatık and Akdeniz 2019) in which responses of industrial production are not highly sensitive to interest rate shocks for Turkey. Also, following an unexpected rise in the policy rate, the domestic currency appreciates, signaling the absence of exchange rate anomalies contrary to previous findings (see Varlık and Berument 2017) that find exchange rate puzzles against a shock to the lending rates. These results also confirm the orthodox policy-making of raising the rates of interest and providing an overvalued domestic currency in the early 2000s in Turkey (Yeldan and Ünüvar 2016).

Figure 2 also reveals that the producer price index (PPI) is affected negatively and pronouncedly by a positive policy innovation starting from the second period while the negative response of the consumer price index (CPI) is quite modest. This result is not compatible with the literature that reaches significant and adverse impacts on CPI inflation of policy rate shocks in Turkey (Varlık and Berument 2017; Bilge Küçükefe and Dündar M. Demiröz 2018). In our case, the moderate response of CPI may signal more of an indeterminacy state (see, Anatoliy Belaygorod and Michael

Dueker 2007) where the monetary policy is reluctant in controlling CPI inflation aggressively using the policy rate changes (Efrem Castelnuovo and Paolo Surico 2010; Gürkaynak et al. 2015). This finding can be attributed to the existence of a trade-off in the provision of price stability, financial stability, and economic growth in policy-making (Yeldan and Ünüvar 2016; CBRT 2021a).



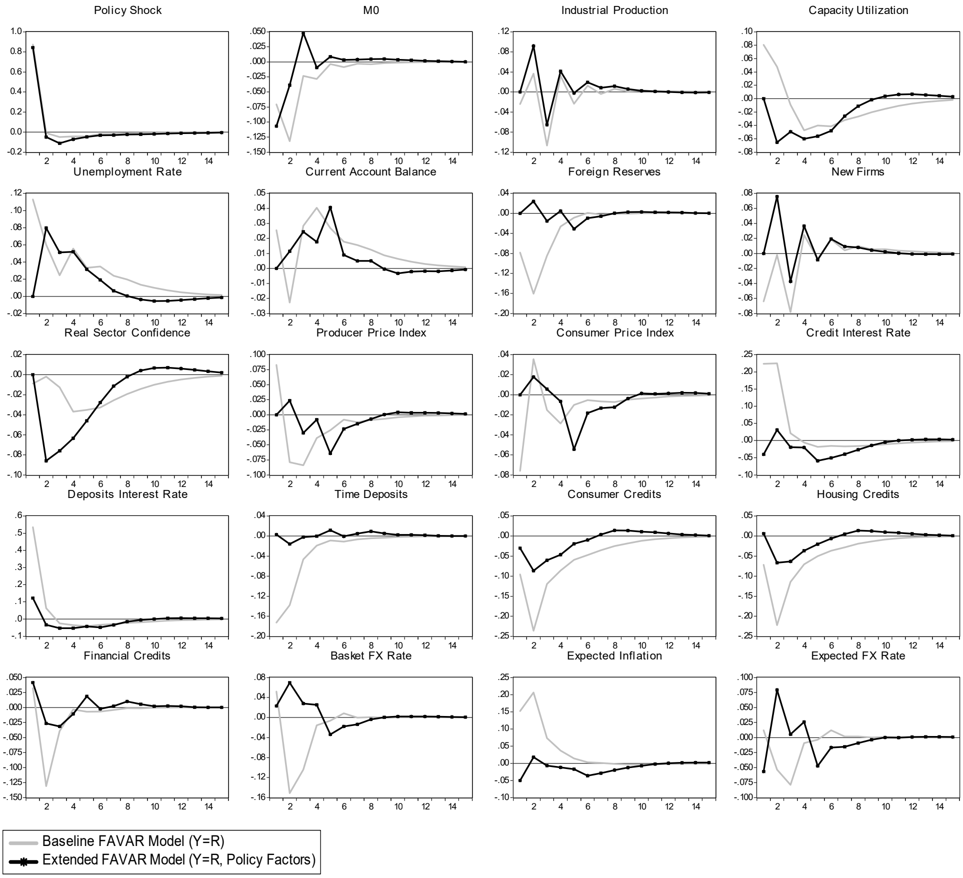
Source: Author's calculations.

Figure 2 Impulse Response Functions to a Shock to the Policy Rate under Baseline Model

A positive innovation to the policy rate in the baseline model passes through bank credit and deposit interest rates. A policy disturbance positively affects credit interest rates, and credit loans (consumer, housing, and financial credits) decrease. This result is contrary to findings that discredit the policy rate for the pricing of loan/deposit rates (Binici, Kara, and Özlü 2018). The figure displays that consumer loans (consumer and housing credits) are more responsive to unexpected policy shocks compared to corporate loans (financial credits). Further, the short-term adverse relationship between the policy rate and the money stock signals the functioning of the liquidity effect (Kelly, Barnett, and Keating 2011). Finally, being different from the response of CPI inflation, a positive shock to the policy rate leads financial agents to expect higher inflation at the end of the year in the Turkish economy.

5.2 Extended Model

The extended model builds upon Varlık and Berument (2017). However, contrary to this study, we calculate rotated factors in a way that eliminates the likelihood of contemporaneous covariance between fast-moving series and the monetary policy factors (see Section 3). In this way, we intend to build weights of common factors correctly and prevent a potential overestimation of responses to the selected policy shock under consideration. In contrast to Varlık and Berument (2017), who use only the IC_2 test, we use a panel of information criteria to set the number of factors. As the optimal number of factors is sensitive to the information criteria selected and the number of factors determines the impulse responses of variables, we made a detailed analysis of the determination of the number of factors. Also, we defined AIC and BIC as functions of both T and N to be compatible with the FAVAR model. Further, we utilize a recursive-design residual bootstrap algorithm in obtaining consistent confidence bands instead of one-standard deviation intervals.



Source: Author's calculations.

Figure 3 Impulse Response Functions to a Shock to the Policy Rate under Baseline and Extended Models

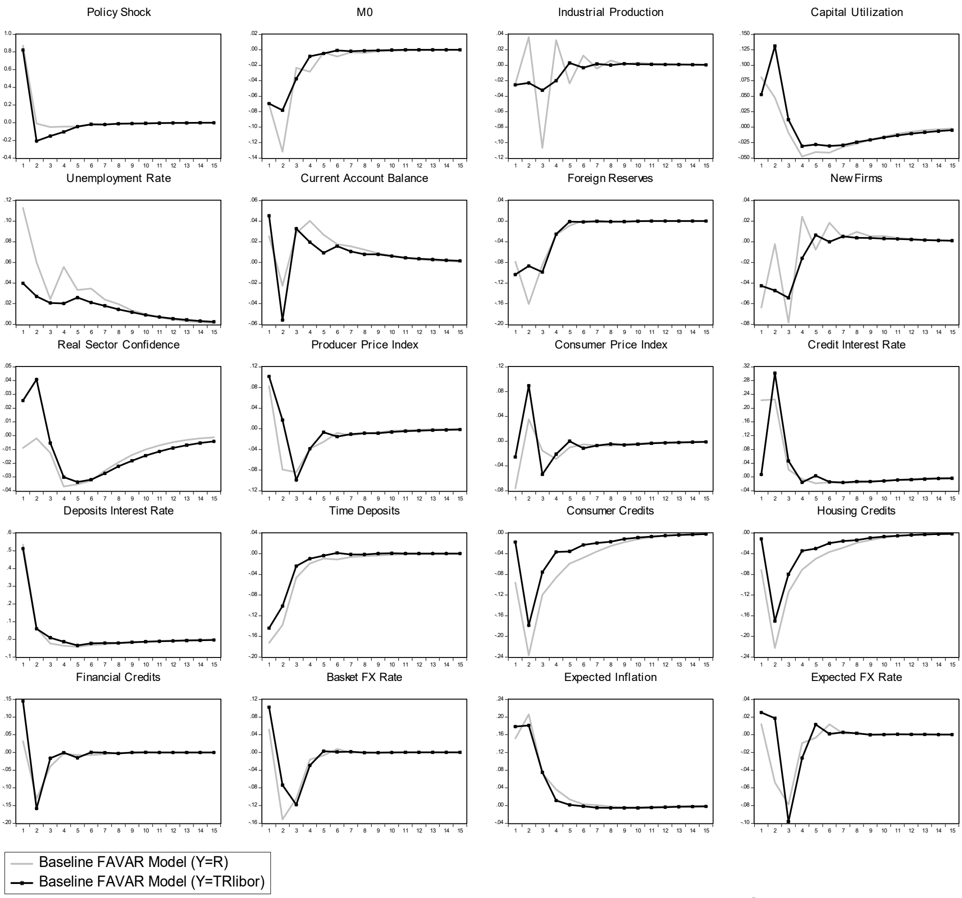
Figure 3 displays the results of the baseline and extended models. We determined the number of monetary policy factors as two, which explains 58% of the total variation in the data set using 15 monetary instruments (see the Appendix for details). With the use of the extended model, we examine the effectiveness of the policy rate controlling for the common components of policy instruments applied by the central bank. In broad strokes, we determine that the officially announced interest rate becomes weaker in affecting economic state variables under a multiple-policy environment. This result strongly promotes the findings that the policy rate is a poor indicator of the policy stance in Turkey operating under an asymmetric corridor (Binici, Kara, and Özlü 2018; Serçin Şahin and Serkan Çiçek 2018).

Following a positive innovation to the policy rate, the response of real activity under the extended model does not feature a different pattern from the baseline model. The impact on industrial production, among others, is limited and insignificant. The responses of aggregate price indexes materialize as insignificant under the extended model. Further, the pass-through impact on loan and deposit markets is quite low compared to that in the baseline model. Both consumer and financial credits respond less to a positive shock to the policy rate controlling for the multiple policy environment. This result now confirms the arguments that stand against the effectiveness of the policy rate in successfully penetrating the credit markets in the Turkish economy (Binici, Kara, and Özlü 2018). Regarding the response of expectations, we observe first that the positive response of expected CPI inflation for the end of the year vanishes and becomes insignificant under the extended model. Further, the expected exchange rate responds surprisingly as positive to a positive policy shock.

5.3 Baseline Model with TRLIBOR Rate

The TRLIBOR rate is advocated in the literature as a reference rate in summarizing the central bank's policy set (see Harun Alp et al. 2010; Gürkaynak et al. 2015). The Banks Association of Turkey (TBB) established the TRLIBOR market to build a reference interest rate among the banks and their clients. The TRLIBOR (ask or bid) rate is calculated by the TBB with a random selection of quotations entered by the participating banks five times for O/N, weekly, monthly quotations and taking the arithmetical average of the entered values, excluding the highest and lowest values (Fatih Akçelik and Anıl Talaslı 2020). We use the end-of-month observations of weekly TRLIBOR ask rates to obtain monthly rates.

In the first place, it arises that both the policy rate and the TRLIBOR rate reveal very similar response patterns for almost all series (Figure 4). One exception is that following a shock to the TRLIBOR rate, the fall in real sector confidence becomes more consistent. Further, the transmission of a TRLIBOR rate shock to credit interest rates occurs with a delay. That the policy rate and the TRLIBOR rate generate parallel responses on the selected economic indicators can be attributed to the fact that the participating banks bear strongly in mind the existing and expected policy rates while setting their quotation rates. Further, the existence of a close co-movement between these two rates is observed in the literature (see Alp et al. 2010).



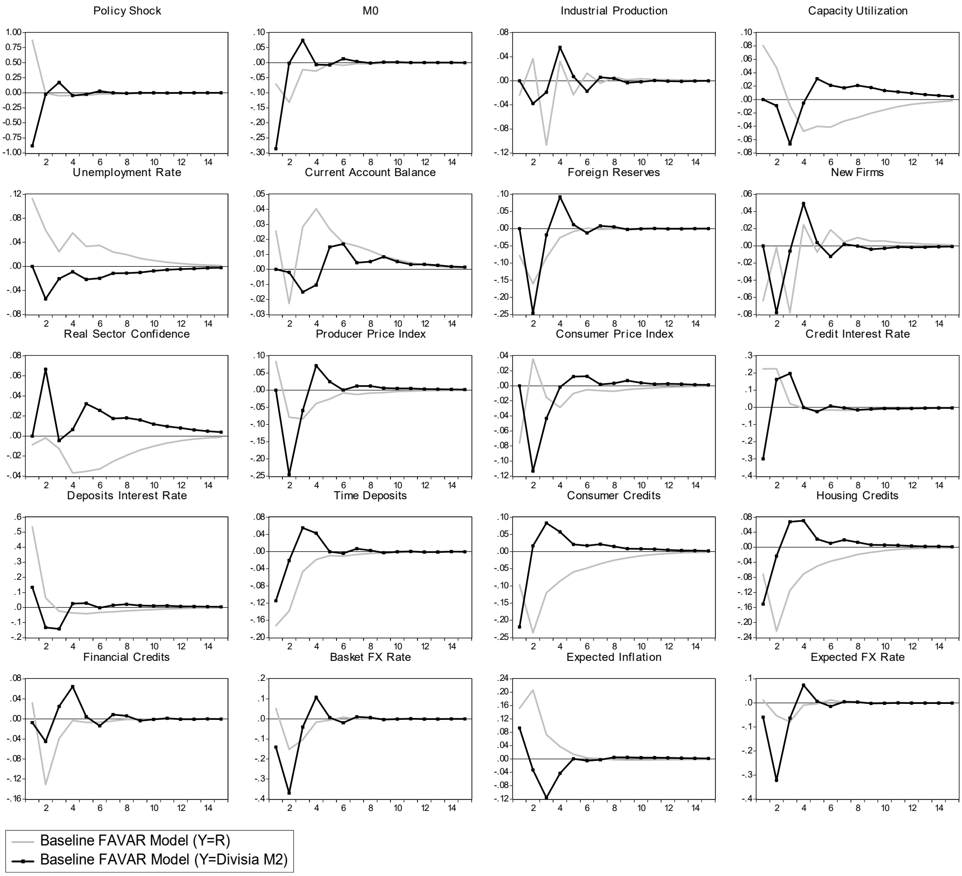
Source: Author's calculations.

Figure 4 Impulse Response Functions to a Shock to the Policy Rate and TRLIBOR Rate under Baseline Model

5.4 Baseline Model with Divisia M2

To see the effectiveness of money supply shocks in monetary transmission, we analyzed impulse responses of economic variables assuming a disturbance to money under the baseline model. For this aim, we constructed and used Divisia-type monetary aggregates instead of officially announced simple-sum aggregates to stand for the money stock. Simple-sum aggregates are argued to result in puzzling behaviors during the pass-through of monetary policy (Keating et al. 2016), overstate the total stock of money (Barnett, Barry E. Jones, and Travis D. Nesmith 2008) and hide the expected liquidity effects following a change in the money supply (Kelly, Barnett, and Keating 2011). Therefore, Divisia-type monetary aggregates due to Barnett (1978, 1980) are proposed as a theoretically convincing monetary instrument in the policy-making that can solve the deficiencies attributed to simple-sum aggregates (Barnett and Marcelle Chauvet 2011; Ryan S. Matsonn 2013; Michael T. Belongia and Peter N. Ireland

2014). Market interest rates are included in the construction of Divisia monetary aggregates, and monetary assets are distinguished according to their user costs. In this way, transition dynamics across assets and changes in liquidity conditions are tracked better (Kelly, Barnett, and Keating 2011). Thus, we constructed broadly defined Divisia money aggregates and tested the relative transmission power of Divisia money against the policy rate. For convenience, we explain the conceptual framework and data set used in the computation of the Divisia index in the Appendix.



Source: Author's calculations.

Figure 5 Impulse Response Functions to Shocks to the Policy Rate and Divisia M2 under Baseline Model

A one-standard deviation is used to define the money shock (Figure 5). Following a negative disturbance to money, responses of the real activity variables feature expected patterns and are relatively short-lived compared to responses following the policy rate shock. However, the response of unemployment is puzzling and negative following a contractionary money supply shock. A money supply shock results in a more robust and instantaneous decline in the responses of the basket exchange rate compared to a policy rate shock. Also, replacing policy rate disturbances with money supply disturbances provides consistent estimates in response to the prices. That is, the monetary contraction through the monetary aggregates is significantly deflationary. Indeterminacy in the response of CPI inflation to policy rate shock, thus, disappears in this setting. The PPI inflation is still more responsive to the Divisia shock compared to CPI inflation. Also, we determined that shocks to Divisia aggregates do not transmit effectively to the credit market compared to shocks to the policy rate. First, both credit and deposit rates do not respond properly to money disturbances. While the loan market responds negatively and instantaneously to a money shock, the related impact is short-lived and vanishes after the first quarter. Following a negative money disturbance, agents' expectations on both inflation and exchange rates are negatively and robustly affected, which is not observed in the case of policy rate shocks.

5.5 Variance Decomposition and R^2

Results for the forecast error variance decomposition (FEVD) and R^2 analyses are given in Table 3 to shed better light on the performance of the policy shocks under different specifications and common factors in estimation. The FEVD reports the fraction of the variance of the forecast error of each variable explained by the policy shock. Let $\hat{X}_{t+h|\mathrm{t}}$ be the h-horizon ahead forecast of X_{t+h} at t and let forecast error be $X_{t+h} - \hat{X}_{t+h|\mathrm{t}}$. Hence, the part of the variance of the forecast error due to monetary policy disturbances, ε_t^r, can be given as $\frac{\mathrm{var}(X_{t+h}-\hat{X}_{t+h|\mathrm{t}}|\ \varepsilon_t^r)}{\mathrm{var}(X_{t+h}-\hat{X}_{t+h|\mathrm{t}})}$. Further, being intrinsic to FAVAR models, R^2 reports the explanatory power of common components for the variance of each variable. It corresponds to the part of the variance of each variable explained by $\hat{F}_t$ and Y_t in Equation (2). A high value of R^2 denotes that information contained in the selected variable is well summarized by the common factors (Soares 2013).

First, the commonly held argument on the low contribution of policy shocks to the volatility of real activity variables (Christiano, Eichenbaum, and Evans 1999; Bernanke, Boivin, and Eliasz 2005; Soares 2013) is also valid in our model: under different models, the impact is less than 3%. Table 3 reveals that policy shocks under alternative models explain a relatively larger fraction of the forecast error of PPI inflation compared to the CPI. Further, money supply shock leads to higher volatility of aggregate price indexes and exchange rates than policy rate shocks. Further, we observe that the forecast error of financial loans is less responsive in all specifications relative to that of consumer loans. Regarding the R^2 decomposition analysis, Table 3 displays firstly that common components perform well in explaining the variance of the selected variables with certain exceptions. The explanatory power of common components is particularly high for industrial production, real sector confidence, consumer loans, and exchange rates, while for the unemployment rate, current account balance, time deposits, and financial loans the performance of the common components are not equivalently satisfying. This provides that we need to be less convenient in interpreting impulse responses for the latter group of variables. Also, while defining policy shocks under alternative models does not dramatically alter the R^2 (which promotes the arguments for the modest place of the unsystematic component of the monetary policy in affecting state variables), shocks to the policy rate under the extended model provide the highest explanatory power for the Turkish case.

Table 3 Forecast Error Variance Decomposition and R^2 for Selected Variables

Variables	Baseline (Y=R)		Extended (Y=R, Policy Factors)		Baseline (Y=TRLIBOR)		Baseline (Y=Divisia M2)	
	FEVD*	R^2	FEVD*	R^2	FEVD*	R^2	FEVD*	R^2
M0	2.2	14.9	2.1	18.6	1	15.4	8.2	17.5
Industrial prod.	1.3	91.6	1.2	92.9	0.3	91.4	0.3	91.4
Capacity utilization	1.9	57.9	1.7	59.5	2.6	58	0.9	58.7
Unemployment rate	2.3	33.7	2.1	35.3	0.6	33.4	0.5	33.7
CA balance	0.3	26.3	0.4	28	0.9	26.3	0.1	26.4
Foreign reserves	3.7	41.7	3.3	43.3	2.6	44.3	6.4	42.5
New firms	1	49	0.9	50.3	0.7	48.9	0.6	48.8
Real S. confidence	0.2	72.3	0.4	75.6	0.8	72.3	0.4	72.3
Producer price index	2.2	56.9	2.1	59.6	2.5	57	6.7	56.3
Consumer price index	0.7	39.4	0.6	42.7	1.3	38.7	1.4	38.9
Credit interest rate	10.6	63.9	8.3	65.1	9.6	66.4	16.3	63.8
Deposit interest rate	35.3	75.9	32	77.7	31	77.2	7.4	65.6
Time deposits	4.9	23	3.1	25.7	2.3	24.6	1.6	22.1
Consumer credits	9.3	78.8	7.3	79.8	4.7	78.7	6.4	78.7
Housing credits	7.7	62	5.8	63.1	4.6	62.6	3.1	62.4
Financial credits	1.8	30.1	0.5	32.1	4.4	30.7	0.3	32.6
Basket FX rate	3.4	92.4	3.1	93.7	2.8	92.4	14.7	93
Expected inflation	6.8	46.1	5.5	47.4	6	44.9	2.3	47.3
Expected FX rate	0.8	73.1	0.9	74.3	1	73	10.1	73.2

Notes: * The numbers are expressed in percentages. The analysis is provided for a 15-month horizon.

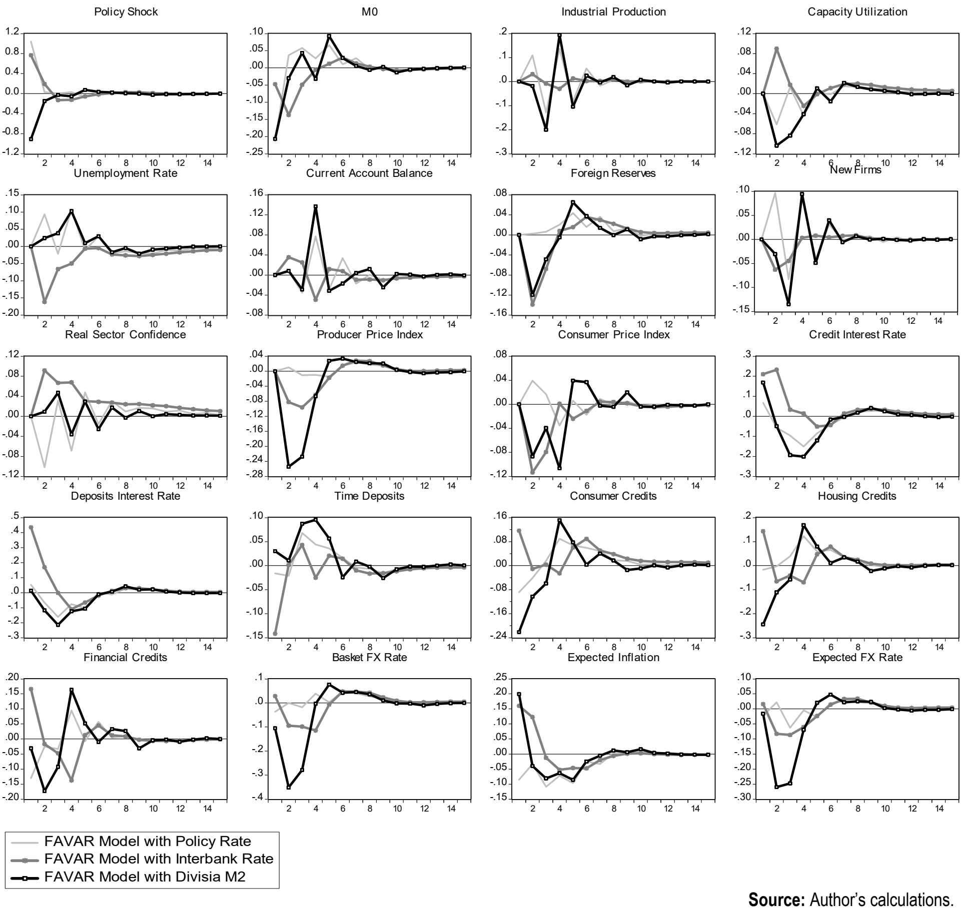
Source: Author's calculation.

6. Robustness Analysis

6.1 New Monetary Policy Period

In this section, we analyze the effectiveness of the policy shocks in the conduct of monetary policy for the period 2011:1-2018:4. This period witnessed a vigorous and simultaneous use of multiple instruments by the CBRT. The bank designed a new monetary policy framework in late 2010 in an attempt to smooth financial volatility and support financial stability (Kara 2013). During this period, the CBRT called for a more cluttered policy stance, allowed market interest rates to diverge from the officially announced rate, and determined the policy rate within a wide interest rate corridor (Kazim A. Özdemir 2015). Thus, we estimate the FAVAR model for this period, acknowledging that the selected policy rate *per se* may not summarize the stance of the monetary policy. Also, as the CBRT is the net lender to banks during this period, it deserves an inquiry to investigate liquidity effects of changes in lending rates set directly or indirectly by the CBRT on the funding needs of agents.

We estimated impulse responses of selected variables to both policy rate and effective rate. We used the one-week repo rate as the policy rate and the BIST overnight interbank repo rate to stand for the effective rate, given findings that interbank rates matter more than officially announced rates for monetary transmission in cases under which the two rates are consistently different (Binici, Kara, and Özlü 2018). Also, the BIST rate is determined indirectly by the interaction of the officially announced rates with central bank funding decisions (Binici, Kara, and Özlü 2018). We also report impulse responses to the Divisia M2 money supply shock controlling the multiple policy framework (see Figure 6). We estimate the extended FAVAR model as it enables us to control for the multiple policy framework.



Source: Author's calculations.

Figure 6 Impulse Response Functions to Shocks to the Policy Rate, Interbank Rate and Divisia M2 under Extended Model

Table 4 provides that all monetary shocks explain industrial production, the number of new firms, price indexes, market rates, credits, exchange rate, and expected exchange rates at a convincingly high rate. Still, we observe a limited impact of policy disturbances on real activity variables as found in previous sections. Interbank rate changes transmit better to market rates compared to the other two instruments, while a Divisia money shock generates more profound impacts on industrial production, producer price index, credit market, and exchange rates. Further, FEVD analysis provides that a policy shock to the Divisia M2 explains 20% of the exchange rate volatility being quite effective relative to the other two tools.

Table 4 Forecast Error Variance Decomposition and R^2 for the Selected Variables: The New Monetary Policy Period

Variables	Policy Rate		Interbank Rate		Divisia M2	
	FEVD*	R^2	FEVD*	R^2	FEVD*	R^2
M0	3.2	24	2.5	28.5	4	27.3
Industrial prod.	1.9	94.6	0.2	95.2	4.5	94.9
Capacity utilization	0.3	22.5	0.1	36.2	3.1	29.5
Unemployment rate	0.9	37.8	3.9	37.3	0.5	36.6
CA balance	0.8	30.9	0.6	32.7	0.5	32.8
Foreign reserves	3.1	41.2	6	44.2	3.3	44.4
New firms	0.7	51.2	0.5	52.9	1.8	52.0
Real sector confidence	1	40	1.2	41.7	0.6	41.4
Producer price index	1.6	64.7	3	64.8	12.1	64.8
Consumer price index	0.8	41.5	2	45.1	1.6	45.9
Credit interest rate	10.3	69.5	13	69.6	9.2	70.4
Deposit interest rate	20.6	66.8	26.8	74.2	7.3	70.6
Time deposits	1.4	28.1	2.2	33.3	1	29.9
Consumer credits	3.4	71.5	1.7	75.8	6.4	72.1
Housing credits	3.2	54.5	2.8	60.6	7.6	54.3
Financial credits	1.7	54.6	2.8	55.4	4.3	56.7
Basket FX rate	1.2	91.3	3.4	91.7	20.4	92.9
Expected inflation	3.7	48.3	4.2	50.7	4.7	50.2
Expected FX rate	1.4	77	2.1	77	11.9	77.8

Notes: * Denotes the percentage. The analysis is provided for a 15-month horizon.

Source: Author's calculation.

For the responses of aggregate price indexes, we observe that the policy rate becomes more passive in coping with CPI inflation compared to the whole sample results. That is, the volatility of inflation is less affected by a shock to the policy rate under the new policy episode (Table 4). This result confirms the multiple-policy environment that de-potentiates the policy rate in coping with a trade-off that might occasionally realize between different objectives (Kara 2013). Replacing the policy rate with the effective rate or money supply and assuming contractionary disturbances, however, result in both PPI inflation and CPI inflation being negatively and significantly affected. In this regard, we do not come across an indeterminacy state when the policy shock is given to the effective rate determined by the central bank's funding policy or the Divisia M2 that includes intrinsically market interest rates.

Credit and deposit rates are relatively more responsive to interbank rate disturbances, confirming the findings of Binici, Kara, and Özlü (2018). The overall impact on the loan market is most pronounced when policy innovation is defined over the Divisia money. The negative and significant response of financial and consumer loans to the money shock persists for one quarter and vanishes in subsequent periods. Further, the transmission of policy rate shocks to the exchange market and expectations is not robust in the new monetary policy period. Contractionary shocks to the effective rate as well as Divisia money, however, result in negative and significant effects on exchange rates and expectations.

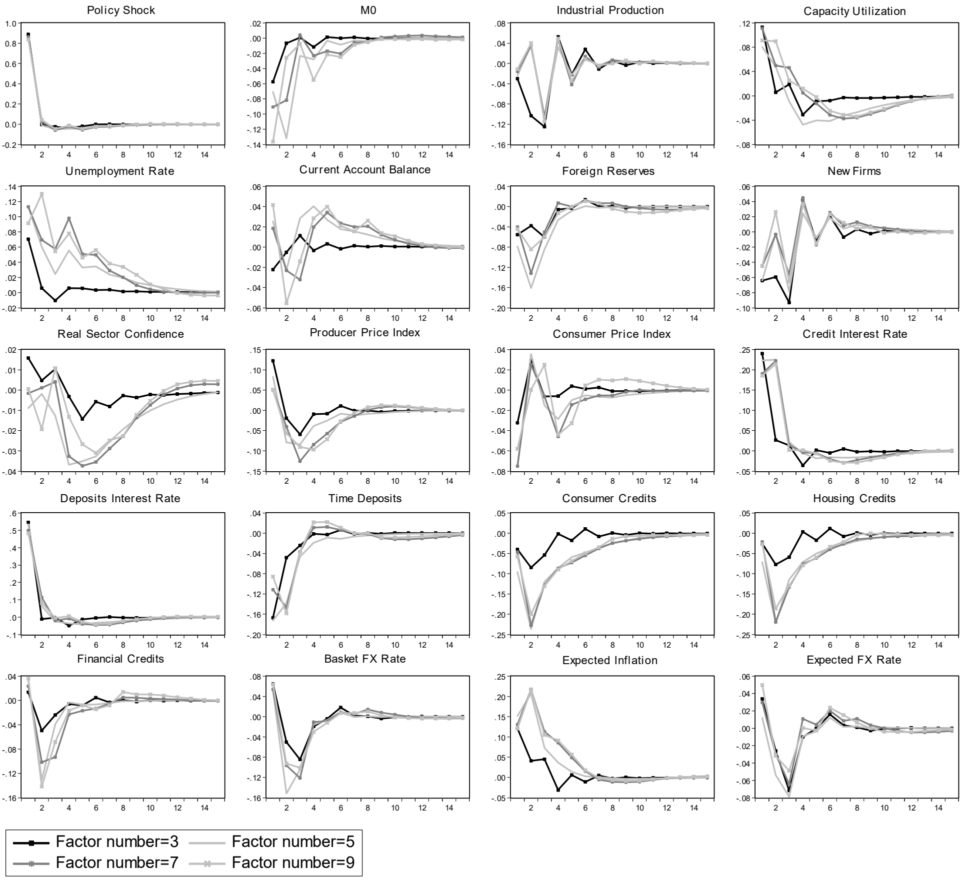
6.2 Response Functions with Different Numbers of Factors

We also controlled whether our results are robust to changes in factors. Figure 7 displays impulse responses to the policy rate shock under the baseline model for different numbers of factors $(k = 3, 5, 7, 9)$. We observed that increasing the number of estimated factors does not dramatically change response patterns. Considering a relatively small number of factors $(k = 3)$, however, results in different patterns. The pass-through to the credit market, for instance, becomes weak with $k = 3$. Also, increasing the number of factors from 5 to 7 or 9 does not markedly improve the performance of the model except for variables of money supply, deposits, and unemployment rate.

7. Conclusion

This study analyzes the effectiveness of the pass-through in the conduct of monetary policy in Turkey. More specifically, we investigated the extent to which changes in the policy rate that the monetary authority periodically announces to operate the markets, aggregate demand, and expectations penetrate the targeted variables. That the central bank's tool basket has become heavier and arguments favoring effective rates compared to policy rates in transmission to the economy have been articulated on the one hand, and that the central bank clamorously announces its loyalty to the policy rate on the other hand, motivated us in such an inquiry. Utilization of the FAVAR model enabled us to reveal the strength of the transmission mechanism to all series included in the data set rather than only to aggregate economic indicators. Also, as the sample period includes both conventional and new monetary policy periods, instead of modeling the time variation in estimation, we preferred to estimate the latter period separately for robustness. We also evaluated the effectiveness of policy rates in a comparison of different choices of policy instruments, i.e., TRLIBOR rate, BIST overnight rate, and Divisia money.

In broad strokes, estimated factors along with policy tools perform well in ex plaining the variance of selected variables. The explanatory power of the model is particularly satisfying for industrial production, real sector confidence, consumer loans,



Source: Author's calculations.

Figure 7 Impulse Response Functions to Policy Rate Shock with Different Numbers of Factors

and exchange rates, while it does not perform quite so well in explaining unemployment rate, current account balance, time deposits, and financial loans. We found that defining policy disturbances under alternative specifications does not dramatically alter the model fit. This might promote arguments for a modest place for unsystematic components of monetary policy in passing through markets. Moreover, the extended model that considers the multiple policy framework features the highest explanatory power for almost all variables.

Under different model formations, contractionary policy rate disturbances lead largely to a small decline in real activity indicators, an appreciation of domestic currency implying no exchange rate puzzles, no liquidity anomalies guaranteed by a fall in the monetary aggregates or credits, and indeterminacy in responses of aggregate price indexes. Moreover, we observed that the policy rate becomes consistently weaker in affecting the variables of interest controlling the multiple policy framework. This observation supports the literature that regards the policy rate as a poor indicator of policy-making in Turkey when the multiple policy framework is considered. The policy rate disturbances pass less effectively through the loan market under the extended model. Also, Divisia money shocks resulted in more consistent but short-lived effects on aggregate price indexes, solving the indeterminacy state which is observed under policy rate changes. In addition, when the effectiveness of officially announced interest rates under the unconventional policy period is examined, we observe that the performance of one-week repo rates is significantly poorer compared to BIST interbank repo rates. The policy rate becomes more passive in coping with CPI inflation during this period and an indeterminacy state in the response of CPI inflation vanishes when the policy innovation is defined by the interbank rate or the Divisia M2 that includes, by formation, market interest rates.

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Appendix

Table A1 Description of the Data

#	Description	S/F	Tr.	Source
	Domestic Series			
1	Industrial Production Index (IP) (2010=100) (SA)	S	5	TUIK
2	IP - Intermediate Goods (SA)	S	5	TUIK
3	IP - Durable Consumption Goods (SA)	S	5	TUIK
4	IP - Nondurable Consumption Goods (SA)	S	5	TUIK
5	IP - Energy (SA)	S	5	TUIK
6	IP - Capital Goods (SA)	S	5	TUIK
7	Number of Registered Motor Vehicles (SA)	S	5	TUIK
8	Capacity Utilization Rate	S	2	CBRT
9	Unemployment Rate (SA)	S	4	TUIK
10	Unemployment Rate - Excluding Agriculture (SA)	S	4	TUIK
11	Current Account Balance (Million Turkish Lira - TL)	S	5	CBRT
12	Capital + Financial Account Balance (Million TL)	S	5	CBRT
13	Net Errors and Emissions (Million TL)	S	5	CBRT
14	Reserve Assets (Million TL)	S	5	CBRT
15	Net Exports (NX) - Gold (Million TL)	S	5	CBRT
16	Net Exports - Energy (Million TL)	S	5	CBRT
17	Foreign Currency Reserves (Million TL)	S	5	CBRT
18	Gold Reserves (Million TL)	S	5	CBRT
19	Banks' Correspondence Accounts (Million TL)	S	5	CBRT
20	Short-term External Debt (Million TL)	S	5	TUIK
21	Long-term External Debt (Million TL)	S	5	TUIK
22	NX - Consumption Goods (Million TL)	S	5	TUIK
23	NX - Intermediate Goods (Million TL)	S	5	TUIK
24	NX - Capital Goods (Million TL)	S	5	TUIK
25	Budget Expenditures Excluding Interest Payments (Million TL) (SA)	S	5	MTF
26	Interest Payments (Million TL) (SA)	S	2	MTF
27	Number of New Residential Buildings	S	2	TUIK
28	Number of New Firms	S	5	TUIK
29	Consumer Confidence Index (2003=100)	S	2	TUIK
30	Real Sector Confidence Index (2005=100) (SA)	S	2	TUIK
31	Producer Price Index (PPI) (2003=100)	S	5	TUIK
32	PPI - Mining and Quarrying	S	5	TUIK
33	PPI - Manufacturing	S	5	TUIK
34	PPI - Electricity Production and Distribution	S	5	TUIK
35	Consumer Price Index (CPI) - (2003=100)	S	5	TUIK
36	CPI - Food and Soft Drinks	S	5	TUIK
37	CPI – Alcoholic Drinks and Tobacco	S	5	TUIK
38	CPI - Clothing and Shoe (SA)	S	5	TUIK
39	CPI - Housing, Water, Electricity, Gas and Fuels	S	5	TUIK
40	CPI – Furniture	S	5	TUIK
41	CPI - Health	S	5	TUIK
42	CPI - Transportation	S	5	TUIK
43	CPI - Communication	S	5	TUIK
44	CPI - Education (SA)	S	5	TUIK

45	CPI - Restaurants and Hotels	S	5	TUIK
46	CPI - Agricultural Products	S	5	TUIK
47	General Living Index - Wage Earners (2005=100)	S	5	TUIK
48	Currency	F	5	CBRT
49	M1	F	5	CBRT
50	M2	F	5	CBRT
51	M1 (Divisia)	F	5	CBRT + Author's calculation
52	M2 (Divisia)	F	5	CBRT + Author's calculation
53	M1 including Participation Banks	F	5	CBRT
54	M2 including Participation Banks	F	5	CBRT
55	M1 including Participation Banks (Divisia)	F	5	CBRT + Author's calculation
56	M2 including Participation Banks (Divisia)+	F	5	CBRT + Author's calculation
57	Sight Deposits	F	5	CBRT
58	Time Deposits	F	5	CBRT
59	Time Deposits - Foreign Currency	F	5	CBRT
60	Credits (Non-financial Companies) (Million TL)	F	5	CBRT
61	Credits (Small Companies) (Million TL)	F	5	CBRT
62	Credits (Consumers) (Million TL)	F	5	CBRT
63	Credits (Housing) (Million TL)	F	5	CBRT
64	Credits (Cars) (Million TL)	F	5	CBRT
65	Credits (Need) (Million TL)	F	5	CBRT
66	Credits (Over Credit Cards) (Million TL)	F	5	CBRT
67	Credits (Financial Companies) (Million TL)	F	5	CBRT
68	5-Year CDS premium	F	5	Bloomberg
69	Real Effective Exchange Rate (CPI Based) - (2003=100)	F	5	CBRT
70	Exchange Rate (U.S. Dollar)	F	5	CBRT
71	Exchange Rate (Euro)	F	5	CBRT
72	Exchange Rate (Basket Rate)	F	5	CBRT
73	BIST 100 - Stock Market Index (1986=1)	F	5	Bloomberg
74	Gold Selling Price	F	5	Bloomberg
75	CPI - Expectation - End of the Year	F	2	CBRT
76	Exchange Rate - Expectation (U.S. Dollar) - End of the Year	F	5	CBRT
77	Current Account - Expectation - End of the Year	F	5	CBRT
78	GDP Growth - Expectation - End of the Year	F	4	CBRT
79	Interest Rate on Credits (Needs)	F	4	CBRT
80	Interest Rate on Credits (Cars)	F	4	CBRT
81	Interest Rate on Credits (Housing)	F	4	CBRT
82	Interest Rate on Credits (Commercial)	F	4	CBRT
83	Interest Rate - 1 Year Government Bond	F	4	CBRT
84	Interest Rate on Deposits - 1 month	F	4	CBRT
85	Interest Rate on Deposits - 3 month	F	4	CBRT
86	Interest Rate on Deposits - 6 month	F	4	CBRT
87	Interest Rate on Deposits - 1 year	F	4	CBRT
88	Interest Rate on Deposits (Foreign Currency) - 1 month	F	4	CBRT
89	Interest Rate on Deposits (Foreign Currency) - 3 month	F	4	CBRT
90	Interest Rate on Deposits (Foreign Currency) - 6 month	F	4	CBRT
91	Interest Rate on Deposits (Foreign Currency) - 1 Year	F	4	CBRT
	External Series			
92	CBOE volatility Index (Foreign Series)	F	2	FRED
93	STOXX 50 Volatility Index (Foreign Series)	F	2	Reuters

94	Euro/Dollar Parity (Foreign Series)	F	5	ECB
95	Federal Funds Rate (Foreign Series)	F	4	FRED
96	S&P 500 PE Ratio (Foreign Series)	F	2	Bloomberg
97	3-Month London Interbank Offered Rate (Foreign Series)	F	4	FRED
98	Europe Brent Spot Price (Foreign Series)	F	5	FRED
	Monetary Policy Instruments			
99	Rediscount Rate	F	4	CBRT
100	Advance Interest Rate	F	4	CBRT
101	Overnight Borrowing Rate	F	4	CBRT
102	Overnight Lending Rate	F	4	CBRT
103	Late Liquidity Window Borrowing Rate	F	4	CBRT
104	Late Liquidity Window Lending Rate	F	4	CBRT
105	One Week Repo Auctions Rate[++]	F	4	CBRT
106	Weighted Average of Cost of Funding[+++]	F	4	CBRT
107	Ratio of Open Market Operations to Total Assets of CBRT	F	4	CBRT
108	Required Reserve Ratio – TL	F	4	CBRT
109	Required Reserve Ratio - Foreign Currency	F	4	CBRT
110	BASE MONEY	F	5	CBRT
111	BIST Overnight Interbank Rate[++++]	F	4	CBRT, FRED
112	The Turkish Lira Interbank Offered Rate	f	4	TBB
113	Policy Rate	F	4	CBRT

Notes: CBRT - Central Bank of the Republic of Turkey; TUIK - Turkish Statistical Institute; MTF - Ministry of Treasury and Finance of the Republic of Turkey; FRED - Federal Reserve Bank of St. Louis; TBB - The Banks Association of Turkey. S/F shows whether the variable is treated as “slow-moving” (S) or “fast-moving” (F) in the first stage of the estimation. Tr. shows how the variable is transformed to have approximate stationarity: 2 means the variables in logarithm, 4 means the first difference and 5 means logarithmic-difference. (SA) shows the series that are seasonally adjusted. [+] The monetary aggregates calculated using the Divisia Index (DM1PARTC and DM2PARTC) are not used in calculation of the factors and are controlled as the alternative policy instruments. [++] Since the one-week repo rates are not available until 2010:5 we use the lending rate accordingly for the missing observations. [+++] Observations for the average funding cost are available starting from 2011:1. [++++] To set the interbank rate, we use the CBRT overnight interbank repo rate until 2010:12 and the BIST overnight interbank repo rate thereafter. * shows the time series which are corrected for their outliers using the technique in Stock and Watson (2005).

Source: Author’s compilation.

Bootstrapping Confidence Bands

Each variable included in X and each factor in F is standardized. The unobserved factors in F are extracted using PCA. Loadings Λ and VAR residuals $\phi(L)$ are obtained with the OLS. The estimation of the orthogonal invertible matrix A is made by taking the inverse of Cholesky decomposition. To obtain the confidence bands for the IRFs, the bootstrap procedure is employed by re-sampling the factors grounded on the observation Equation (2) and, conditional on the rotated factors, by bootstrapping the VAR coefficients in the transition Equation (1). The related bootstrapping procedure is based on the recursive-design residual bootstrap algorithm and can be summarized in the following steps:

Step 1: To extract F from X, perform the PCA and standardize F to have zero mean and one standard deviation.

Step 2: Estimate model parameters Λ and $\phi(L)$ with the standardized X and standardized F from the VAR model. Generate residuals e and v of reduced form Equations (2) and (1), respectively. Then generate IRFs.

Step 3: Determine the number of replications R and the level of significance α.

Step 4: Generate v^* by uniformly sampling columns belonging to v with replacement. Next, generate recursively pseudo common forces F^* (see Equation (1)) using v^*, $\phi(L)$ and randomly selected initial values of F. Next, make F^* standardized and name it as $\hat{F}^*$. Generate e^* by uniformly sampling columns belonging to e with replacement. Next, generate pseudo observed endogenous time series X^* (see Equation (2)) using e^*, Λ and $\hat{F}^*$. Next, make X^* standardized and name it as $\hat{X}^*$. Estimate Λ^* and $\phi(L)^*$ using $\hat{X}^*$, $\hat{F}^*$ and A^* which is recalculated with $\hat{F}^*$(see Equation (6)). Next, generate impulse responses with the bootstrapped estimates and data.

Step 5: Repeat Step 4 for R times ($r = 2,3 \dots, R$).

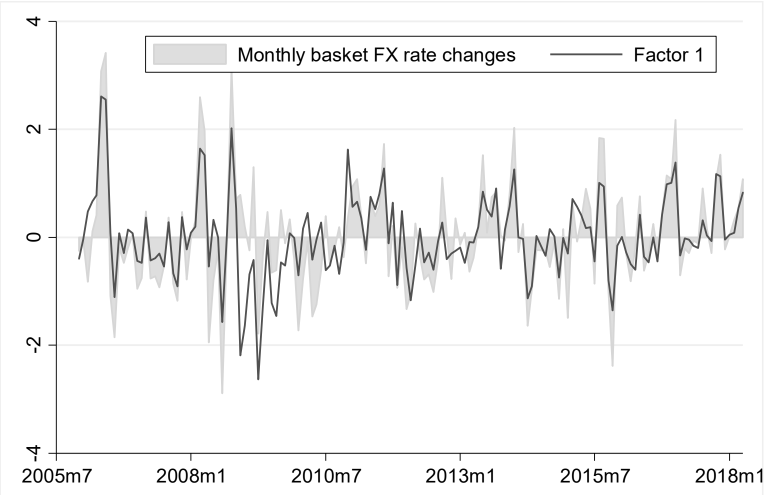
Step 6: Produce bootstrapped confidence bands for the impulse responses generated in Step 2 based on the bootstrap distributions in Steps 4 and 5.

Table A2 Pearson Correlation Coefficients between Factors and Macroeconomic Variables

	Exchange rate (basket rate)	0.838***
	Long-term external debt	0.826***
Factor 1	Current account - expectation - end of the year	0.679***
	Short-term external debt	0.651***
	Real effective exchange rate	0.647***
	Credits (consumer loans)	0.625***
	Credits (cars)	0.562***
Factor 2	Consumer confidence index	0.555***
	Credits (housing)	0.545***
	Industrial production index (capital goods)	0.542***
	Industrial production index	0.661***
	Industrial production index (intermediate goods)	0.646***
Factor 3	Industrial production index (nondurable consumption goods)	0.626***
	Number of new firms	0.592***
	Number of registered motor vehicles	0.583***
	Industrial production index	0.550***
	Industrial production index (intermediate goods)	0.544***
Factor 4	M2	-0.545***
	Interest rate on credits (cars)	0.487***
	Industrial production index (energy)	0.483***
	Consumer confidence index	-0.559***
	Current account balance	0.463***
Factor 5	Consumer price index	-0.448***
	NX - capital goods	0.378***
	Unemployment rate	0.371***

Notes: *** shows the statistical significance levels for Pearson coefficients at 1%.

Source: Author's calculation.



Source: Author's calculations.

Figure A1 Fitted Value of the Regression with Factor 1 and Basket FX Rate Changes

The Conceptual Framework of the Divisia Index

Divisia-index-based monetary services can be described as follows: Let m_{it}^{real} stand for the stock of monetary asset i in real terms for period t such that $m_t^{real} = (m_{1t}^{real} \dots m_{nt}^{real})$ arises as the vector of real stocks and m_{it}^{nom} is the nominal stock of asset i for period t such that $m_t^{nom} = (m_{1t}^{nom} \dots m_{nt}^{nom})$. In this regard, stocks of monetary assets in real and nominal terms are linked by the identity $m_{it}^{real} = (m_{it}^{nom}/P_t^*)$, where P_t^* shows the true cost of living index of the consumer. In defining the user cost of assets, let π_{it}^{nom} show the nominal user cost of asset *i* in period *t*, r_{it} denotes the nominal return on asset *i* in period *t* and R_t shows the nominal return on the benchmark asset in period *t*. Then, the user cost of asset *i* in period *t* is equal to the value of a return forgone due to holding this particular asset, i.e., $p_t^*(R_t - r_{it})$, discounted by the term $(1 + R_t)$ (Richard G. Anderson, Barry Jones, and Travis Nesmith 1997). That is, $\pi_{it}^{nom} = \frac{p_t^*(R_t - r_{it})}{(1+R_t)}$ and $\pi_{it}^{real} = \frac{R_t - r_{it}}{1+R_t}$. In the next step, the total expenditure on each monetary asset (Y_t) is calculated as $Y_t = \sum_{i=1}^{n} \pi_{it}^{real} m_{it}^{nom}$. This implies that the total expenditure function is not contingent upon P_t^* and is reached using solely stocks and user costs. Then, the share of each asset in the total expenditure function is as $w_{it} = \left(\frac{\pi_{it}^{real} m_{it}^{nom}}{y_t}\right) = (R_s - r_{is}) m_{is}^{nom} / \sum_{i=1}^{n} (R_s - r_{js}) m_{js}^{nom}$. Therefore, using the nominal money stocks and the corresponding rates of returns, the (Törnqvist-Theil) nominal Divisia index of monetary services DM_t^{nom} is measured as $DM_t^{nom} = DM_{t-1}^{nom} \prod_{i=1}^{n} \left(\frac{m_{it}^{nom}}{m_{it-1}^{nom}}\right)^{\overline{w}_{it}}$ where $\overline{w}_{it} = \frac{1}{2}(w_{it} + w_{it-1})$. Note that the simple sum index SS_t can simply be described as $SS_t = \sum_{i=1}^{n} m_{it}^{nom}$.

The Data Set Used in Computation of the Divisia Index

The Divisia monetary aggregates are constructed by covering both deposit money banks and participation banks. The period is from 2005:12 through 2018:4. It is given the monetary assets and corresponding rates of return data in computation of Divisia aggregates in Tables 3 and 4. Also, Figure 2 represents the annual growth rates of simple sum M2, constructed Divisia M2, and the benchmark interest rate. We first determined that no aggregation error is contained in the Divisia aggregates. Further, the forecasting exercises provide that the Divisia monetary aggregates give smaller forecast errors (of MAE and RMSE) of prices and quantities compared to simple sum aggregates[3].

Table A3 Monetary Assets Used in Computation of Monetary Aggregates

Monetary assets	Frequency	Sample period
M1		
Currency in circulation (deposit banks)	Weekly	2005.M12-2018.M6
Sight deposits denominated in turkish lira (deposit banks)	Weekly	2005.M12-2018.M6
Sight deposits denominated in foreign currency (deposit banks)	Weekly	2005.M12-2018.M6
Sight deposits denominated in turkish lira (participation banks)	Monthly	2005.M12-2018.M5
Sight deposits denominated in foreign currency (participation banks)	Monthly	2005.M12-2018.M5
M2 = M1 +		
Time deposits denominated in turkish lira with different maturities (deposit banks)*	Weekly	2005.M12-2018.M6
Time deposits denominated in foreign currency with different maturities (deposit banks)	Weekly	2005.M12-2018.M6
Time deposits denominated in turkish lira with different maturities (participation banks)*	Monthly	2005.M12-2018.M5
Time deposits denominated in foreign currency with different maturities (participation banks)	**Monthly**	**2005.M12-2018.M5**

Notes: * Time deposits are divided among one-month, three-month, six-month and one-year, and more and depending on their unit of currency.

Source: Author's compilation.

Table A4 Interest Rate Series Used in Computation of User Costs

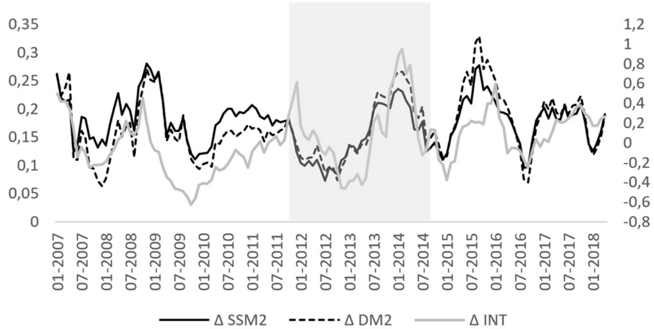
Interest rate series	Frequency	Sample period
Deposit banks		
Interest rates on sight deposits denominated in Turkish lira and foreign currency*	Weekly	2005.M12-2018.M6
Interest rates on (up to) 1-month time deposits denominated in Turkish lira and foreign currency**	Weekly	2005.M12-2018.M6
Interest rate on (up to) 3-month time deposits denominated in Turkish lira and foreign currency	Weekly	2005.M12-2018.M6
Interest rate on (up to) 6-month time deposits denominated in Turkish lira and foreign currency	Weekly	2005.M12-2018.M6
Interest rate on (up to and more than) 1-year time deposits denominated in Turkish lira and foreign currency	Weekly	2005.M12-2018.M6
2-year government bond yields***	Weekly	2005.M12-2018.M6
Participation banks		
The profit share on (up to) 1-month time deposits denominated in Turkish lira and foreign currency****	Monthly	2005.M12-2018.M5
The profit share on (up to) 3-month time deposits denominated in Turkish lira and foreign currency	Monthly	2005.M12-2018.M5
The profit share on (up to) 6-month time deposits denominated in Turkish lira and foreign currency	Monthly	2005.M12-2018.M5
The profit share on (up to) 1-year time deposits denominated in Turkish lira and foreign currency	**Monthly**	**2005.M12-2018.M5**

Notes: * Yields on sight deposits that deposit banks bear correspond to the weighted average of rate of returns for sights in TL and foreign currency. The rates of returns series are flow variables and correspond to observations at the end of the period. Note that starting from December 2010 the effective maximum interest rates for sight deposits were obligated by the Central

[3] Details on the construction of Divisia-type monetary aggregations with Turkish data, bootstrap algorithm used to obtain confidence bands as well as the impulse response functions to different policy shocks with 10% confidence intervals are available upon request.

Bank to be set to 0.25%. ** Yields on time deposits that the deposit banks bear with different maturities correspond to the weighted average of rate of return for deposits in TL and foreign currency. *** The rate of return on two-year government bonds that encounter coupon payments every three or six months is selected as the benchmark rate. **** The profit shares on the funds raised in the deposit accounts in Turkish lira and foreign currency correspond to weighted averages of resultant profit or loss shares of five participation (Islamic) banks in Turkey, i.e., Albaraka, Kuveyt Türk, Türkiye Finans, Vakıf Participation, and Ziraat Participation.

Source: Author's compilation.



Notes: The figure indicates the year-on-year change in simple sum and Divisia aggregates under the benchmark index (Δ SSM2 and Δ DM2) on the left axis and year-on-year change in 2-year government bond yields (Δ INT) on the right axis. The period is from 2007:1 through 2018:4.

Source: Author's calculation.

Figure A2 Annual Growth Rates of the Simple-Sum M2, Divisia M2, and the Benchmark Interest Rate