THE IMPORTANCE OF EXTERNAL SHOCKS AND GLOBAL MONETARY CONDITIONS FOR A SMALL-OPEN ECONOMY

by

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This is to certify that I have examined this copy of a master's thesis by

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ABSTRACT

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The purpose of this study is to assess the role of the domestic and foreign shocks for a small-open economy. As an emerging market, Turkey's main macroeconomic aggregates are examined during the sample period, 2003-2018. The domestic supply, demand and domestic monetary policy shocks as well as their global counterparts are identified by employing a small-scale Bayesian Structural VAR model. In the model, the algorithm of the Arias et al. (2014) is used by utilising both sign and zero restrictions to disentangle the structural shocks driving the economy, with the block exogeneity assumption due to Turkey's being a small economy such that the shocks originated from Turkey can not affect that of the foreign variables in the model, i.e. the FED funds rate, global demand indicator and the price of oil. The results imply a significant depreciation of the Turkish lira, a fall in the real output level and the rise in overall price level in the economy after a US monetary tightening. Moreover, there has been a positive policy reaction by the Central Bank of the Republic of Turkey after a US monetary tightening. The forecast error variance decomposition point out that while for the price and the output level, the foreign and domestic shocks make up approximately the same amount of the variation, for the Central Bank of the Republic of Turkey's main policy rate and the exchange rate, the impact of the external shocks dominates. The thesis contributes to the literature in three ways. From a methodological point of view, I identify the main global and domestic shocks by combining sign and zero restrictions in the structural impact matrix for the Turkish economy. From an economic point of view, I assess the repercussion effect of global oil price and global demand shocks along with the (un)conventional FED monetary policies while taking into account of the Zero Lower Bound period on real and financial responses of the Turkish economy. From a policy perspective, I provide an evidence that a small-open emerging economy with flexible exchange rates is not completely insulated from global real and monetary shocks so that the identification of both domestic and foreign shocks matters for economists and policy makers and should be taken into account seriously.

Keywords: Bayesian VAR, SVAR, sign and zero restrictions, shock identification, oil, monetary policy, Turkey.

ÖZET

DIŞSAL ŞOKLARIN VE KURESEL PARASAL KOŞULLARIN KUÇUK-AÇIK BİR EKONOMİ İÇİN ONEMİ

Gülnihal TÜZÜN
Ekonomi, Yüksek Lisans
Tez Danışmanı: Dr. Oğretim Üyesi Cem Çakmaklı
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Bu çalışmanın amacı yerli ve yabancı şokların Türkiye ekonomisindeki rolünü analiz etmektir. Gelişmekte olan bir ülke olarak Türkiye, 2003-2018 dönemi arasında Türkiye'nin esas makroekonomik değişkenleri incelenmiştir. Yerli arz, talep ve para politikası şokları ile bunların küresel karşılıkları küçük ölçekli bir Bayesçi Yapısal Vektör Özbağlanım modeli ile tanımlanmıştır. Modelde, Arias et al. (2014) 'nın algoritması ile işaret ve sıfır kısıtları kullanılarak ekonomiyi sürükleyen yapısal şoklar ayrıştırılmış ve Türkiye'nin küçük bir ekonomi olup dışsal değişkenleri (FED faiz oranı, küresel talep göstergesi ve petrol fiyatları) etkileyememesi özelliği ile de blok dışsallık varsayımı yapılmıştır. Sonuçlar, Amerika'daki bir parasal sıkılaşma sonucunda Türk Lirasının değer kaybettiğini, çıktı seviyesinde azalış ve fiyat seviyesinde artış gözlendiğini ima etmektedir. Ayrıca, FED'in faiz artırımından sonra Türkiye Cumhuriyet Merkez Bankası'ndan da pozitif yönde bir politika faizi artışı tepkisi görülmektedir. Fiyat ve çıktı seviyelerindeki varyasyonu tahmin etmek için, yabancı ve yerli şoklar yaklaşık olarak eşit role sahipken, Türkiye politika faizi ve kur seviyesinde ise dışsal şokların etkisinin domine ettiği görülmektedir. Bu tez literatüre üç şekilde katkı yapmaktadır. Metodolojik bir perspektiften, temel küresel ve yerli şoklar işaret ve sıfır kısıtları ile yapısal etki matrisine tanımlanmış ve incelenmiştir. İktisadi bir perspektiften, küresel petrol ve talep şokları ile FED'in geleneksel (ve geleneksel olmayan) para politikası şoklarının Türkiye ekonomisine reel ve finansal etkileri analiz edilmiştir. Politika çerçevesinden ise, küçük-açık ve serbest döviz kuru rejimine sahip bir ülke olarak küresel reel ve parasal şoklardan ayrı bir politika analizinin düşünülemeyeceği ve söz konusu şokları tanımlamanın ve ayrıştırmanın politika yapıcılar ve ekonomistler için önemli olduğu sonucuna ulaşılmıştır.

Anahtar sözcükler: Bayesçi VAR, SVAR, işaret ve sıfır kısıtları, petrol, para politikası, Turkiye.

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To my mother, Saniye Tüzün.

Contents

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List of Abbreviations

CBRT **C**entral **B**ank of the **R**epublic of **T**urkey

CPB **C**entraal **P**lan**B**ureau, Netherlands Bureau for Economic Policy Analysis

EM **E**merging **M**arket

FED **FED**eral Reserve

FEVD **F**orecast **E**rror **V**ariance **D**ecomposition

HD **H**istorical **D**ecomposition

MFD **M**undell **F**leming **D**ornbusch **M**odel

SOE **S**mall **O**pen **E**conomy

ZLB **Z**ero **L**ower **B**ound

Section 1

Introduction

Macro-economists have long been involved in the investigation of the drivers of the fluctuations of certain macroeconomic indicators regardless of the country-specific characteristics of the markets in concern. Because the level of the economic globalisation process has reached a stage that necessitates a considerable degree of interconnection among both advanced and emerging economies, evaluating the countries independent from rest of the world and engaging in policy making in an isolated way is inappropriate and removed from both empiric and theoretical ideas.

In such a financially and economically interconnected environment, it is of great interest and importance for policy makers to identify the sources of the main macro variables of the Turkish economy. Conventional and unconventional monetary policies began to be co-adopted to curb adverse impact of the Global Financial Crisis (GFC). This has lead to discussions about international monetary spillovers from advanced economies to emerging ones. The period immediately after the GFC, when the advanced economies' central banks adopted excessively expansionary monetary policies to be able to stimulate the economy and to recover from low inflationary periods, the global liquidity indicators measuring the total foreign exchange rate denominated capital flows to the emerging countries (retrieved from BIS Statistics, 2019) have exhibited peak levels. In the midst of the GFC, that indicator decreased approximately around 8 percent on a quarterly basis. During 2010, there has a 13.5 percent quarterly change observed in total amount of capital flows through the emerging market economies. As the empiric analyses prove the existence of a global financial cycle whose main determinants is the monetary policies conducted by the core economies (Rey, 2015), it is worth examining the connections between advanced economies' policies and their repercussions to small open economies. In light of these, there are certain central questions regarding the fluctuations in the emerging market economies (EME's) that have been open to debate for many decades. These can be specified but are not limited to the following: To what extent are the macroeconomic fluctuations in emerging markets originated from abroad? In particular, considering the fact that the developments in the US economy have effects beyond its shores, to what extent are the fluctuations in emerging markets caused by the US monetary policies? What is the role of the global supply and demand shocks, their connection with the U.S economy, and how they are transmitted to emerging economies?

These central questions have brought about certain discussions regarding the modelling problems in small open economies as well as their advanced counterparts. Because the analysis results are sensitive to the identification of models where the variables are endogenously determined in a dynamic system, it is of high importance that the shocks governing the overall economy are determined and identified well. This is particularly true when the country in concern is a small open economy where the identification gets more difficult. The empirical studies on the effects of monetary policy shocks in EM economies have reported certain puzzling dynamic responses when inappropriate identification schemes are used (Cushman and Zha, 1997). To amend this, the adoption of a structural model is proposed by Cushman and Zha (1997), and Kim and Roubini (2000), among many authors working on the open economy macroeconomics. When the standard models' variables ordered recursively by a causal chain link logic, certain puzzles are inevitable. They are called puzzles because a shock to the system fails to generate an empirically and theoretically anticipated response. To be more specific, for instance, *liquidity puzzle* is generally observed when monetary policy shock is attempted to be represented by changes in monetary aggregates (Sims, 1992). Instead, employing short-term interest rates is proposed which, in turn, produces the *price puzzle* which is when a contractionary monetary policy results in an increase in the price level. Following that, to avoid encountering such puzzles, Cushman and Zha (1997) proposed relying on structural VAR models. Therefore, to alleviate the widely observed puzzles[1] in the literature, employing a structural vector autoregressive model with correctly identified shocks is essential in open economy macroeconomics discussions.

In this thesis, I estimate the outlined key questions empirically using the data of one of the emerging economies, Turkey. To be more specific, I estimate a two country Structural VAR

[1]The most common ones are the price, exchange rate and liquidity puzzles (see Sims (1992), Grilli et al. (1995)).

(SVAR) model estimated with Bayesian techniques by using sign and zero restrictions of main domestic and foreign shocks on the impulse-response functions of the variables in concern. First, a foreign monetary shock is described in the model with the simultaneous inclusion of the standard domestic shocks. The foreign monetary shock is represented by an interest rate hike in effective FED funds rates. This is then followed by the inclusion of global aggregate demand and global aggregate supply disturbances into the system. The identified shocks are aimed at assessing the responses of the following domestic variables: domestic output, price level, exchange rate, and the Central Bank of the Republic of Turkey's (CBRT) policy rate to the shocks identified in each scheme. With such a system in which both domestic and foreign shocks are identified seperately, the aim of this research is to shed light on the potential shock transmission channels on domestic variables and to assess how the global and foreign shocks interact with one another. Although there is a vast amount of literature on the transmission channels and the spillover effect of US monetary policy on both advanced and emerging economies, reviewing the impact of global supply and global demand disturbances along with the US monetary shock on Turkey remains a gap in the literature. Similar research have been done for the euro area economies (Jarocinski and Bobeica, 2017; Conti et al., 2017; Hajek and Horvath, 2018), for United States (Conti, 2017). However, the global monetary shocks along with global supply and demand shocks have not been examined in detail for the Turkish economy, to the best of my knowledge.

The remainder of the thesis is structured as follows: Section 2 outlines a brief literature review, Section 3 introduces the structural VAR methodology used in this thesis, discusses the reasons for this modeling choice and describes and motivates the identification strategy, Section 4 presents the empirical evidence, Section 5 displays some further specifications for robustness checks and Section 6 summarizes the findings and makes conclusion.

Section 2

Related Literature

There are two important channels on which the consequences of international transmission of monetary policy rely. First is the trade balance effect, and the second is the foreign output effect. The Mundell-Fleming-Dornbusch model postulates that a monetary expansion leads to a real exchange rate depreciation which in turn, results in an increase in the net exports of an economy (the expenditure switching effect). Due to resulting rise in income, the domestic import demand increases too; thus, this could worsen the trade balance (income-absorption effect). According to the inter-temporal model, the previously improved current account which was improved via consumption-smoothing with a temporarily raised income, may worsen after the rise of the investments and imports.

The second channel works as follows: After a monetary expansion in a foreign country, the trade balance (in other countries) can worsen (via *the expenditure-switching effect* through the goods and services preferred in the country where expansionary monetary policy is employed) and by a decrease in foreign output (*the beggar-thy-neighbor policy*). This is one possible case, unless a possible reversal via the income-absorption effect takes place. The inter-temporal model also advocates a possible expenditure-switching mechanism (with the appreciated domestic currency assumption) resulting in a decrease in the foreign output. On the other hand, due to the fall in world real interest rates, (assuming that the expansionary monetary policy is executed by an advanced, core economy like US), the demand for goods may rise and lead to a growth in foreign output stemming from the periphery economies. The ambiguous effects via the MFD model and the inter-temporal models remain valid in the current literature, and empirical evidence is needed for more clarification.

The effects of US monetary shocks by employing structural VAR modelling have been previously studied by Sims (1980), Cushman and Zha (1997), and Kim (2001). Cushman and Zha (1997) proposed a structural model for Canada. The authors take into account a scheme which is appropriate for the features of a small open economy setting. Their studies criticise the recursive identification structure of the traditional vector auto-regressive models by asserting that the recursive approach to monetary policy identification for small economies is not appropriate while that scheme is valid for a large, relatively closed economy such as the United States since the estimated responses of the variables have been in line with conventional analysis (Sims, 1992; Eichenbaum and Evans, 1995). Because the central banks in small-open economies respond to the foreign shocks, recursive identification schemes are deemed to be inappropriate where the domestic economy variables are allowed to affect that of the foreign ones after the initial period of a shock's occurrence. It is, therefore, predicted that a recursive scheme produces typical puzzles. The authors find plausible evidence that US contractionary monetary shock spills over to Canada as Canadian interest rates rise and the currency appreciates while the latter impact is more strongly pronounced.

Kim (2001) documented the transmission of US expansionary monetary policies on G-7 countries with a resulting boom in the advanced economies. In this boom, it is reported that the fall in world interest rates play a greater role than the changes in the trade balance. In that sense, neither the MFD model nor the inter-temporal models seem to explain the international monetary policy repercussions. Contrary to previous findings, the author demonstrated that, after controlling for inflationary and supply side shocks (by adding a commodity price index into models in an attempt to solve the price puzzles in the models), the non-US G-7 countries' monetary policies do not closely follow the US monetary authorities.

Kim and Roubini (2000) used a structural VAR approach with non-recursive contemporaneous restrictions[1]. The authors modelled the reaction function of monetary authorities and the economy. Based on the proposition by Cushman and Zha (1997), they distinguished money supply shocks from money demand shocks to address the liquidity puzzle and they modelled structural restrictions across equations rather than using a recursive approach and included a price measure to remove the price puzzle. The results are consistent with predictions of the theoretical models: the price puzzle is resolved, and the exchange rate puzzle is removed with a delay of few periods in accordance with the uncovered interest rate parity condition.

[1] Putting restrictions on the matrix which links the reduced form errors terms to the structural disturbance terms.

Their study provides a robust evidence of how structural models can alleviate the problem of puzzles prevalent in both closed and open economies.

Canova (2005) investigated the transmission of US shocks to Latin American countries. The chosen countries spans both small and large economies and those having fixed and flexible exchange rate regimes. From the previous literature, the author identified and extracts several sources of US structural shocks and quantifies their impact on Latin American economies. He reported that US real demand and supply shocks have insignificant variations in a typical Latin American economy, whereas the US monetary shocks generate significant responses in macroeconomic variables with an instantaneous transmission in timing. The importance of the interest channel appears to be more significant compared to the trade channel and he found significant evidence that a contractionary US monetary shock induces a rapid increase in Latin American interest rates accompanied by capital inflows, price level increases, depreciation of the domestic real exchange rates, and a rise in net exports. Similar to the previously discussed literature, American macroeconomic variables explain most of the variance in the Latin American variables, while there are no significant discrepancies encountered in empirical evidence in terms of the transmission mechanism between the floaters and the non-floaters.

Maćkowiak (2007) built a structural VAR model for each emerging market for selected East Asian and Latin American countries. He found that external shocks are an important source of macroeconomic fluctuations in emerging markets. Specifically, a US monetary policy shock immediately disturbs the interest rates and the exchange rates in an emerging market and it reflects upon the price level measures with a delay. However, the output levels' responses are mixed due to the several reasons. First, depreciated exchange rates can induce a rise in net exports (the expenditure-switching effect for the rest of the world). Second, due to higher interest rates, consumption and investment may fall leading to a contraction in the output. Therefore, that these channels that are at odds with each other explain why the higher foreign interest rates' impact on output is mixed and, in certain cases, even muted. The author also concludes that US monetary policy shocks explain a larger fraction of the variance in price and output level in an EM than of the variance in price and output level that of the US economy itself. This phenomenon is expressed by a phrase in the literature : *"When the US sneezes, emerging markets catch a cold."* Most emprical results support this phenomenon.

Dedola et al. (2017) studied the international spillovers of US monetary policy shocks on 36 advanced and emerging countries. They followed a two-step procedure in which they first extracted US monetary policy shock series by identifying a monetary policy shock in US with a Bayesian Structural VAR model by imposing sign restrictions on certain US variables by following the procedure of the seminal paper of Gertler and Karadi (2015). Next, they regressed other countries variables on the estimated US monetary policy shock series estimated at the first step, similar to other influential studies such as that by Romer and Romer (2004), both at quarterly and monthly frequencies. In most of the countries, a surprise US monetary tightening causes a depreciation and a fall in industrial production and output. In advanced countries, inflation falls, too. What is common across advanced and emerging countries in their findings is that economic activity responds the same way after a US monetary policy tightening as it produces a recession.

Except for the study of Dedola et al. (2017), the aforementioned studies build on two-country, bilateral VAR models which Georgiadis (2016) criticised in his paper about the determinants of the global spillovers of the US monetary policy. He claims that previous research is not informative enough in terms of detecting the reasons for international spillovers for country-specific differences and in terms of a country's degree of being exposed to US monetary policy surprises. Moreover, the author highlights the importance of multilateral nature of the global inter-linkage which US policies are likely to cause as the third-country affect is not present in those studies. Consequently, over the course of studying US monetary policy and its cross-border effects, the importance of taking into account global dimension is highlighted. To this end, certain global VAR (GVAR) models which are a combination of country-specific VAR models in a global setting, are employed in the recent literature by Georgiadis (2016), Chen et al. (2012), and Dees et al. (2010) among others.

Regarding the impact of external shocks on the Turkish economy, the examples from the literature are insufficient, except for the panel studies regarding other emerging markets. The studies controlling for the global shocks for Turkey are limited as well. The study of Kilinc et al. (2014) identifies risk premium and interest rate shocks to account for the domestically originated shocks and commodity prices as well as the global demand to account for the globally originated external shocks. They have reached the conclusion that domestic shocks reduce output and Turkey is significantly affected by the global shocks. Their results are parallel to what I have found in my research. Another study by Ogunc et al. (2018) employed a Bayesian approach but adopted a recursively identified VAR modelling scheme for the inflation dynamics of Turkey. The authors argued that the exchange rate pass through to inflation is stronger than that of the import prices. Another thing to note from their study is that the output shock identified in the paper as having relatively larger credibility bands around the median impulse-responses of the inflation is attributed to the uncertainty of the estimated growth shocks: either being a supply-side or a demand-side growth disturbance impact on the price level is unclear. As the authors highlighted a need for a better identification of the source of the growth disturbances, the main advantage of my model in this thesis disentangles precisely both the internally and the externally originated supply and demand shocks for Turkey.

In terms of more recent literature, there are also certain studies using two-country models directed at the either conventional or unconventional FED or ECB monetary policy shocks on certain countries, such as: Moder (2017) and Hajek and Horvath (2018) for south-eastern European economies, MacDonald and Popiel (2017) for Canada, Jarocinski and Bobeica (2019) and Conti et al. (2017) for the Euro Area. The last two studies focuses on the disinflation period occurred after 2013 in the euro area by incorporating oil supply, global demand and monetary policy shocks into the VAR models. I chosed a strategy relying on a *i.Bayesian VAR* to account for small sample properties, *ii.sign and zero restrictions on the impulse-responses* for the identification of disturbances, *iii.encompassing the global demand and supply shocks* to extract more accurately of the driving forces in the global and domestic economy and *iv.using block-exogeneity feature* to better identify the shocks existing in a small-open economy setting.

Taking into account of all the criticisms directed upon the previous studies, a structural VAR model consisting of both domestic shocks (monetary policy, aggregate domestic supply and demand shocks) and global shocks (Federal Reserves effective funds rate shock as a representative of a global monetary shock, global aggregate supply shock and global aggregate demand shock) is estimated in this thesis. There are also studies linking global and domestic shocks by identifying those disturbances with a structural VAR model with Bayesian estimations (Jovičić et al. (2017) for Croatia, Szafranek et al. (2017) for Poland, Conti (2017) for US, Conti et al. (2017) and Bobeica and Jarocinski (2019) for the Euro area). What is central in those set of studies in recent years is that they use minimum set of restrictions to model both domestic and foreign shocks in a fully identified scheme. The above mentioned papers, as I adopt too, predicate on either previously used or empirically and theoretically plausible sign or zero restrictions in the identification schemes. These restrictions along with the logic behind them is explained in part 4.

Section 3

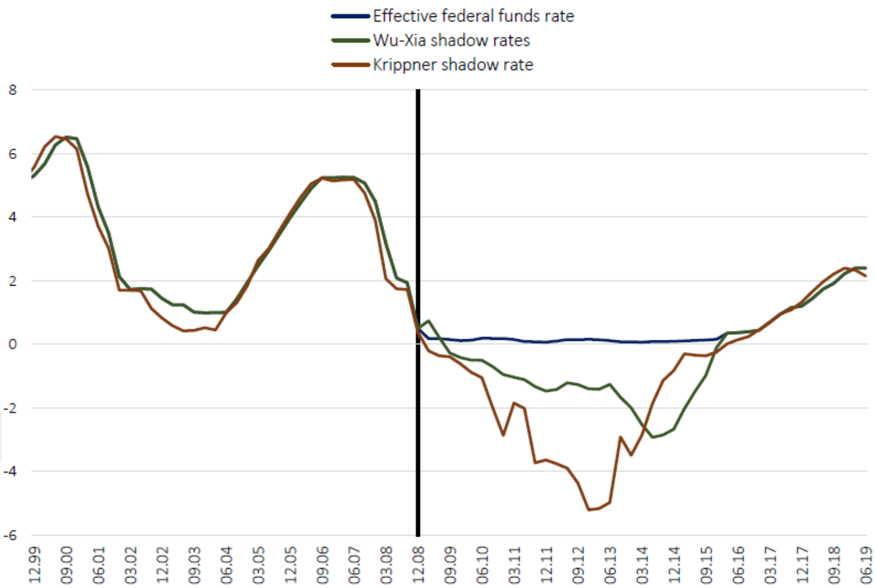
Methodology

3.1 Data

The main research question is to see how the Turkey's main macroeconomic and financial aggregates,i.e the output, price level, exchange rate as well as the CBRT policy interest rate are affected from the global monetary, supply and demand conditions. The data set is composed of two blocks of variables: foreign and domestic. I use quarterly data from 2003:II to 2018:IV.

As a representative of the global monetary conditions, effective federal funds rate is used. The assumption for the choice of FED is because of the global monetary policy conditions are shaped to a great extent by the Federal Reserve whose actions and their repercussions have a great amount of place in the world economy as the changes in US monetary policy has sizeable cross-border impact on domestic activity and global financial markets. After the Global Financial Crisis (GFC), when the conventional, effective Federal Funds Rate hit the Zero Lower Bound (ZLB), in order to stimulate the economy and to recover from disinflationary periods, along with other advanced economies central banks, the Federal Reserve has involved in unconventional policy measures through Large Scale Asset Purchase programs as a tool of the QE period. For the period between December 2008 to December 2015, when the FED funds rate is below 25 basis points *(bps)*, it is inapropriate to use the effective FED funds rate as it fluctuated around the zero bound for a long amount of time, and in particular for most of the estimation period in concern in this thesis. Thus, in order to capture the unconventional policies and to quantify the stance of the monetary policy it is crucial to use the corresponding shadow rates to the QE period (see Figure 3.1). These shadow rates have

Figure 3.1: Comparison of Effective FED funds rate and Shadow Rates



Source: FRED Economic Data, CBRT, Bloomberg

been argued to successfully approximate the monetary policy stance and to account for the ZLB issue. The shadow rates calculated by the Wu and Xia (2016) and the Krippner (2013) are employed in this paper. These shadow rates offer an approximation to a term structure model that is tractable for analysis of the US economy operating near the zero lower bound for interest rates.

To be used in the Baseline model, I add two other global variables into the system: the oil prices and a world industrial production volume excluding construction to proxy a global output/demand variable. For the domestic block, main macroeconomic aggregates of Turkey are used. The output level is real GDP and the price indicator is the consumer price index. USD/TRY nominal exchange rate and the policy rate for CBRT[1] is used as well in the domestic block. For the variables except for the financial ones, *"light transformation"* is adopted on the series to achieve stationary series to be used in the VAR and to achieve stability condition in VARs. All variables are seasonally adjusted (except the financial ones, i.e. the exchange rate and the interest rates) and log-differenced to achieve stationarity, except the FED funds rate and policy rate which entered into VAR system as levels. I

[1]Prior to May 2010, CBRT overnight borrowing rate and after 2010 Q2 the BIST overnight borrowing rate is used.

choose to leave them as in levels not only because of the standard conventions in the related literature but also for the convenience while interpreting the IRF's, to be able to identify my shocks occurring in the initial period in basis points units. The full description of variables, including the list of the series, the source of the data and the applied transformations where used necessary is provided in the Appendix at section B.

3.2 Model

The structural vector autoregressive (VAR) models have been the workhorse of emprical macroeconomics and finance over the last decade as sVARs incorporate additional identifying assumptions motivated based on institutional knowledge or economic theory on model responses in contrast to the standard, reduced-form VAR representations Kilian (2011). Because the traditional VARs are not powerful enough to capture the systematic relationships as the Cholesky decomposition as a semi-structural approach for identification of shocks in a recursive manner, has certain deficiencies, choice of structural models has been heavily preferred in macroeconometric analysis. As the Fry and Pagan (2011) highlights in their paper "The VAR is a reduced form that *summarizes* the data; the SVAR provides an *interpretation* of the data". Since reduced form VAR's do not tell us the dynamics of the economy as the error terms are the contemporaneous relation between the variables, we needed a structural interpretation. As the reduced form VAR summarizes the available information extracted from the data, the SVARs are powerful tools to extract information about the macroeconomy. Ideally we want to see the error terms that are serially uncorrelated and independent of each other such that it carries information regarding the structural and orthogonal shocks. Therefore, structural VARs are important for such purpose. Pinning down from a structural VAR model to reduced form system requires some assumptions about the matrix which forms the relation between the reduced form residuals and the structural disturbances (innovations). This is the *identification* issue. As the Cholesky decomposition only assumes a upper triangular-recursive scheme, for more structural assumptions driving the economy, necessary links must be constructed between foreign and domestic shocks in terms of sign dimension and the periods upon which the shocks are imposed.

The models used in my research are based on sign and zero restrictions by the algorithm developed by the Arias et al. (2014). Throughout the model results, the BEAR Toolbox by Dieppe et al. (2016) is used as it allows structural modelling in a Bayesian setting. I also benefitted from the Grid Search option to optimise the hyperparameters based on the procedures by Giannone et al. (2015). It searches over a certain group of hyperparameters whose lower and upper bounds are given into the system such that the optimal hyperparameters with which the likelihood function is maximized chosen automatically. When no a priori, previously tested hyperparameters are defined for the variables subject to that structural model, grid search is the safest option instead of relying on literature's fixed parameters. Certain hyperparameters are proposed by some leading papers, but they are mostly for US economy and not suitable for small-open economies as it is the main question in my study. Litterman (1986) proposed that the variables containing a unit-root in its first own lags, and zero for other further lags should translate as the first entry being 1 and 0 elsewhere of the β_o, the prior coeffient matrix. In case when the variables are known to be stationary, the first own lag of the variable could be determined as a value less than 1, for instance a value around 0.8 may be preferable in that case. In the estimations, I opted for the Giannone et al. (2015) approach of Grid search to work with hyperparameters that optimally maximize the marginal likelihood of the model, when the system includes to non-stationary variables, i.e. the CBRT policy rates and shadow rates. The detailed parameter values are given in Section 4.

Consider the reduced form VAR(p) model:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \varepsilon_t \tag{3.1}$$

with $\varepsilon_t \sim \mathcal{N}(0, \Sigma)$.

Consider the structural form of the above VAR model.

$$B_0 y_t = B_1 y_{t-1} + B_2 y_{t-2} + ... + B_p y_{t-p} + \eta_t \tag{3.2}$$

with $\eta_t \sim \mathcal{N}(0,\Gamma)$ is the vector of structural disturbances with an orthogonal Γ matrix.

For convenience let,

$$B = B_0^{-1} \tag{3.3}$$

Pre-multiplying both sides of the eqn. 3.2 yields us the following:

$$\varepsilon_t = B\eta_t \tag{3.4}$$

B can be interpreted as a structural matrix linking the reduced-form residuals and the structural disturbances. Note that Eqn. 3.4 implies the following:

$$\Sigma = \mathrm{E}(\varepsilon_t \varepsilon_t\text{'}) = \mathrm{E}(B\eta_t\eta_t\text{'}B\text{'}) = B\mathrm{E}(\eta_t\eta_t\text{'})B\text{'} \tag{3.5}$$

$$\Sigma = B\Gamma B\text{'} \tag{3.6}$$

Here, the aim is for finding B, which is the structural impact matrix. However, there are infinitely many ways to decompose Γ into $B\ B'$, most common ways of which is either recursive identification or sign restrictions approach. The 3.1 can be written as an infinite order MA process as it implies the following sequence:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \varepsilon_t \tag{3.7}$$

$$\Leftrightarrow y_t = (A_1 L + A_2 L^2 + ... + A_p L^p) y_p + \varepsilon_t \tag{3.8}$$

$$\Leftrightarrow (I - A_1 - A_2^{L2} \ldots - A_p L^p) y_t = \varepsilon_t \tag{3.9}$$

$$\Leftrightarrow A(L) y_t = \varepsilon_t \tag{3.10}$$

where $A(L)$ denotes the lag polinominal operator. It is possible to invert this lag polinomial as an infinite order moving average process as:

$$\begin{gathered} A(L)y_t = \varepsilon_t \\ \Leftrightarrow y_t = A(L)^{-1}\varepsilon_t \\ \Leftrightarrow y_t = \sum\nolimits_{i=0}^{\infty} \Psi_i \varepsilon_{t\text{-}i} \\ \Leftrightarrow y_t = \Psi_0 \varepsilon_t + \Psi_1 \varepsilon_{t\text{-}1} + \Psi_2 \varepsilon_{t\text{-}2} + \ldots \end{gathered} \tag{3.11}$$

where the Ψ_i represents the impulse response functions of the reduced form VAR (i.e. the Eqn 3.1). Then, rewriting the 3.11 yields the following:

$$y_t = BB^{-1}\varepsilon_t + \Psi_1 BB^{-1}\varepsilon_{t\text{-}1} + \Psi_2 BB^{-1}\varepsilon_{t\text{-}2} + \ldots \tag{3.12}$$

which in turn implies the following by Eqn 3.4.

$$y_t = B\eta_t + (\Psi_1 B)\eta_{t\text{-}1} + (\Psi_2 B)\eta_{t\text{-}2} + \ldots \tag{3.13}$$

and likewise as follows:

$$y_t = B\eta_t + \tilde{\Psi}_1 \eta_{t\text{-}1} + \tilde{\Psi}_2 \eta_{t\text{-}2} + \ldots \tag{3.14}$$

or

$$y_t = \sum_{i=0}^{\infty} \tilde{\Psi}_i \eta_{t\text{-}i} \tag{3.15}$$

where the $\tilde{\Psi}_0 \equiv B$ and $\tilde{\Psi}_i$'s represent the impulse response functions of the structural VAR.

The reduced-form VAR does not contain any information regarding the matrix B, and because of the unknown B, estimates of the Eqn. (3.1) can not be used to identify the structural error terms. If the reduced VAR model has n variables, B has n^2 elements to be identified and Γ has $n \times (n+1)/2$ elements which makes of total $(n/2)/(3n+1)$ elemtns to identify. Because there are $n \times (n+1)/2$ restrictions are known on B and Γ , there are n^2 restrictions left to be imposed upon to fully identify B and Γ.

By using 3.4 one can formulate the above 3.7 for the IRFs of the structural VAR which can be interpreted as economic meaning with a diagonal Γ.

3.3 Block Exogeneity Feature

Among identification procedures, Cholesky has a lower triangular assumption on B such that $BB' = \Sigma$ while Σ being a symmetric matrix. Ordering from the most exogeneous to the most endogenous variables leads to that contemporaneous restrictions on B. Obviously the Cholesky type of recursive identification does not fit into my concern in my scheme because the domestic variables could have an impact on the foreign ones after the initial period which is unrealistic, considering the emerging markets are small economies not to have impact on the global variables. Therefore, one has to put additional zero restrictions on the remaining period for the impulses coming from domestic shocks to the global, foreign variables.

$$\sum_{s=0}^{p} \begin{bmatrix} A_{11}(s) & A_{12}(s) \\ A_{21}(s) & A_{22}(s) \end{bmatrix} \begin{bmatrix} y_1(t\text{-}s) \\ y_2(t\text{-}s) \end{bmatrix} + \begin{bmatrix} c_{11} \\ c_{21} \end{bmatrix} = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix} \tag{3.16}$$

In the above equation, $\mathrm{y}_1(\mathrm{t})$ represents the vector of macroeconomic variables of the EM's, $\mathrm{y}_2(\mathrm{t})$ represents the variables of the global economy, and vectors c_{11}, c_{21} are constants. Finally, $\varepsilon_1(\mathrm{t})$ and $\varepsilon_2(\mathrm{t})$ denote structural shocks of domestic country and rest of the world, whose mean is zero and variances are $\sum_{\mathrm{i}}$.

For each $\mathrm{A}_{21}(\mathrm{s})=0$, the variables of the EM country are determined to be exogenous to the variable of the rest of the world such that the neither current nor the past (i.e., the lagged values) developments in EM's can not affect the rest of the world due to being a small economy. This assumption is called as the ***block exogeneity*** feature as the foreign variables are exogeneous to those of the SOE. This feature has been introduced firstly by Cushman and Zha (1997) and used later as well by the others: Canova (2005), Maćkowiak (2007) and Dungey and Pagan (2009) who investigated the impact of US shocks on Latin American countries, on East Asia- Latin American emerging markets and on Australian economy, respectively.

Therefore, to be able to both impose block-exogeneity restrictions and to avoid puzzles[2] which are the frequently observed outcomes due to the drawbacks of recursively ordered, Cholesky decomposed semi-structural schemes and improper identification of the VAR models, I prefer to build my models by using Structural VARs with sign and zero restrictions. The main question of interest in my research is how the foreign monetary policies and external shocks affect the small, emerging open economy, in this case is Turkey. In the next sections, I will explain how the algorithm for sign and zero restrictions works and my identification for the initial, small and the full, baseline model.

3.4 Algorithm

The triangular factorization and the Cholesky decompositions are one of the basic schemes in Structural VAR models. As they permit researchers to impose contemporaneous constraints (at the inital period only), the methodology developed by Arias et al. (2014) has an advantage of allowing for putting either magnitude or zero, +, - sign restrictions for any period. These algorithm is adopted by the BEAR Toolbox which is a comprehensive and powerful MATLAB based VAR modelling forecast and policy analysis tool. In this paper, estimations are carried out in the BEAR Toolbox developed by Dieppe et al. (2016).

Consider the Eq. 3.1 and a vector β (a set of the reduced form VAR coefficients A_1, A_2, ..., A_p) and the reduced form's residual covariance matrix Σ. The Ψ_i denote the impulse response functions and let $h(\Sigma)$ be a preliminary structural matrix, where $h(\Sigma)\times \mathrm{h}(\Sigma)' = \Sigma$. From this matrix, obtain a set of structural impulse response functions, $\overline{\Psi_i}$ for i=0,1,2..;

[2]The most common puzzles in the open macroeconomics literature are the price, liquidity and exchange rate puzzles such that all of which is due to encountering contradictory responses of variables after a monetary tightening that are at odds with theoretical, anticipated responses.

$$\overline{\Psi_i} = \Psi_i h(\Sigma) \tag{3.17}$$

To draw from the correct posterior distribution and to implement a orthogonalisation step, draw a random matrix Q from a uniform distribution and define,

$$B = h(\Sigma)Q \tag{3.18}$$

The aim is to draw such an orthogonal Q to preserve this SVAR property 3.5;

$$B\Gamma B' = BIB' = BB' = h(\Sigma)QQ'h(\Sigma') = h(\Sigma)Ih(\Sigma') = h(\Sigma)h(\Sigma') = \Sigma \tag{3.19}$$

$$\Sigma = B\Gamma B' \tag{3.20}$$

Now we need to obtain an orthogonal matrix Q from the uniform distribution. To do so,first draw a n $\times$ n random matrix X from an independent standard normal distribution. Then use QR decomposition of X, such that $X = QR$, with Q an orthogonal matrix and R an upper triangular matrix. Considering the structural impulse responses as:

$$\tilde{\Psi} = \Psi B = \Psi h(\Sigma)Q = \overline{\Psi_i}Q \tag{3.21}$$

and the stacked structural matrix, when the restrictions are implemented for periods p_1, p_2,..., p_n then $f(B, B_1,...,B_p)$ can be written as so:

$$f(B,\ B_1,...,B_p) = \begin{pmatrix} \tilde{\Psi}_{p1} \\ \tilde{\Psi}_{p2} \\ . \\ . \\ \tilde{\Psi}_{pn} \end{pmatrix} = \begin{pmatrix} \overline{\Psi}_{p1} \\ \overline{\Psi}_{p2} \\ . \\ . \\ \overline{\Psi}_{pn} \end{pmatrix} Q = \overline{f}(B,B_1,...,B_p) \times Q \tag{3.22}$$

where

$$\overline{f}(B,B_1,...,B_p) = \begin{pmatrix} \overline{\Psi}_{p1} \\ \overline{\Psi}_{p2} \\ . \\ . \\ \overline{\Psi}_{pn} \end{pmatrix} \tag{3.23}$$

Here, if the restrictions hold, then the

$$S_j \times f_j(B, B_1, ..., B_p) > 0 \tag{3.24}$$

hold for all the shocks j= 1,2,..,n; where f_j(B, B_1,...,B_p) represents the jth column of the matrix f(B, B_1,...,B_p) and where S_j is the restriction matrix with a number of columns equal to the number of rows of f(B, B_1,...,B_p) and a number of rows equal to the number of sign restrictions on shock j. Then keep the matrix Q and go for the next iteration. If the condition (3.24) does not hold, repeat the process from drawing the reduced form coefficients, and Σ and continue the whole algorithm until a valid Q matrix is obtained. A detailed algorithm is given for the above procedure at the Appendix, Section A.

In the algorithm of Arias et al. (2014), Bayesian methodology is used for the determination of the posterior distribution of the two blocks in the VAR analysis, i.e the coefficients of the variables, β's, and the variance covariance matrix,the Σ as its a beneficial tool for dealing with the small-sample properties, while restricting these blocks with a-priori restrictions. I prefer to use the Minnesota prior (which restricts the estimation more than the Inverse-Wishart alternatives) both for the Cholesky decomposition and the structural VAR models due to having a relatively small sample. The Minnesota prior assumes that when a disturbance occurred in the system with a structural shock, the best information of a specific variable comes from the previous realization of that variable. Therefore, Litterman (1986) argued that the further the lag, the more confident one should be that coefficients linked to this lag have a value of zero. Therefore, variance should be smaller on further lags (λ_3). Also, this confidence should be greater for coefficients relating variables to past values of other variables (λ_2). Finally, it should be assumed that little is known about exogenous variables (λ_4), so that the variance on these terms should be large.

Section 4

Identification & Results

In this section, I present how the various shocks and identifications can be used starting from the Cholesky ordering where only timing restrictions apply and pass on to the mix of sign and zero restricted structural VAR models.

4.1 Initial Model

4.1.1 Cholesky Scheme

To see how the Cholesky ordering scheme will apply to our data, the variables in concern are ordered in the following: from the most exogoenous (the foreign block) one to the most endogoneous (the domestic block). Therefore, FED funds rate (Shadow), domestic real GDP, domestic consumer prices, policy rate and the exchange rate is the ordering I adopted. In this ordering, the monetary policy rate is ordered after the real GDP and prices and before the exchange rate. I labeled the first shock as global, denoting the FED funds rate shock and rest as domestic ones. Here, the block exogeneity is applied as well to account for the fact that a small economy can not have enough impact to influence that of the advanced one. With regards to the Baseline Model's Cholesky ordering scheme, the estimation is carried with Bayesian techniques with the Minnesota prior, the corresponding hyperparameters are selected as a result of the Grid Search routine of the Giannone et al. (2015) and the identification schemes are as follows:

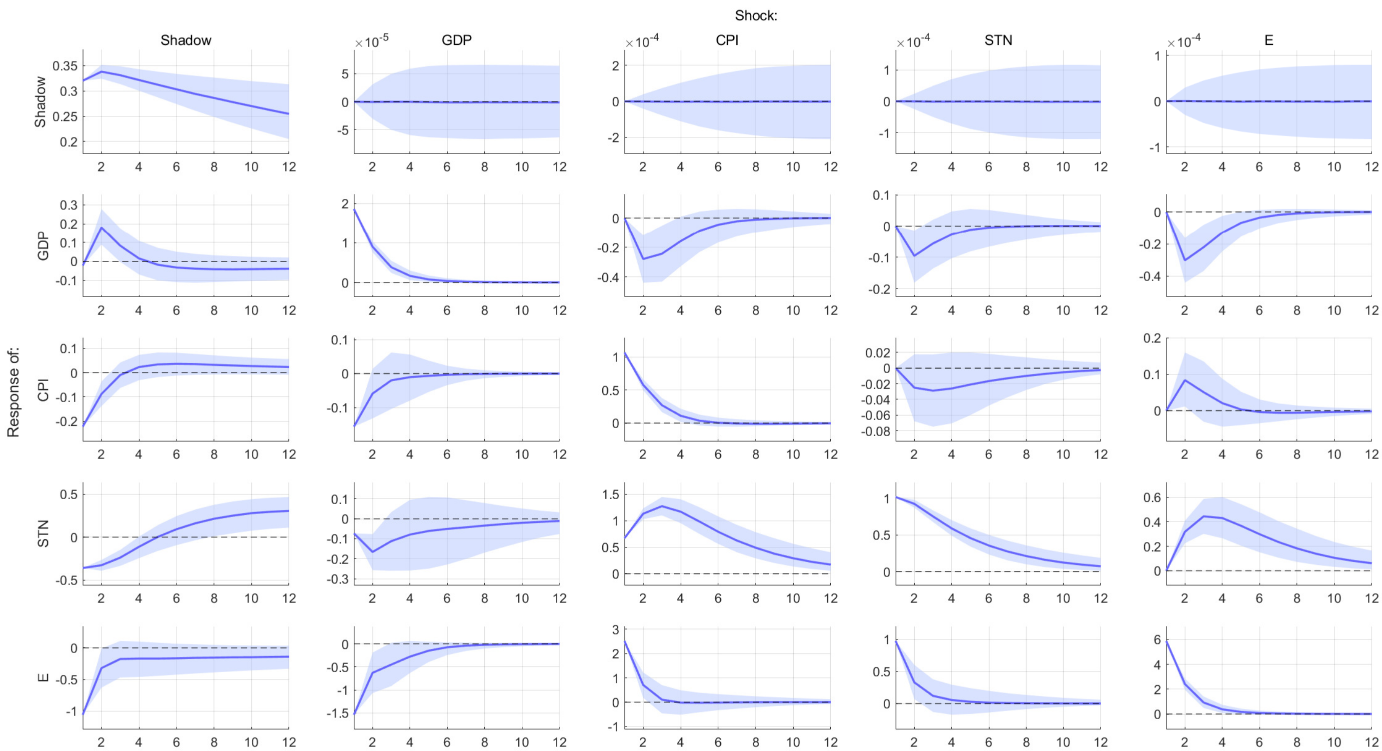
- AR coeffient: 0.7
- Overall tightness (λ_1) = 0.1
- Cross-variable weighting (λ_2) = 1
- Lag decay (λ_3) = 1
- Exogeneous variable tightness (λ_4) = 100
- Block exogeneity shrinkage (λ_5) = 0.001

Table 4.1: **Cholesky Identification Scheme**

Shock/ variable	Global	Domestic	Domestic	Monetary Policy	Exchange Rate
FED funds rate	+	0	0	0	0
Real GDP	•	+	0	0	0
Consumer prices	•	•	+	0	0
Policy Rate	•	•	•	+	0
Exchange rate	•	•	•	•	+

The BVAR estimation yielded the following impulse responses of the Initial Model:

Figure 4.1: **Cholesky Identification Results**



After a contractionary domestic policy rate[1] shock (corresponding to a 100 basis points rise), the output level and the price level decrease as expected. However, exchange rate depreciates too, implying the commonly observed exchange rate puzzle in a typical small-open economy, which requires a structural identification (Cushman and Zha, 1997).

In case of an effective federal funds rate, the real GDP falls on impact which can be explained by the US economy's potential to affect the global demand and liquidity conditions (At that point, one should note that whether the FED responded to its domestic demand conditions or to the global demand conditions is unclear and require a more thoroughly identified scheme which will be added upon the Baseline Model). However, the exchange rate is expected to depreciate as well as a rise in the price level as contrary to the resulting IRF's suggest,

[1] The central bank's policy rate is denoted as STN in the impulse-response functions'(IRFs) graphs throughout the paper.

which apparently can not be observed under this scheme. One thing to note here is that, the policy rate of the Central Bank of Turkey responds negatively to the FED funds rate rise, which is an unlikely stance given a possible exchange rate depreciation and the inflationary pressures in a given quarter in concern, due to the FED's monetary hike. Therefore, there are puzzling results existing when the recursive identification scheme is used in the VAR system to identify the transmission mechanism and the related shocks in the economy. To cope with these puzzling outcomes, zero and sign restricted Structural VAR model is proposed to fully identify the underlying structural shocks in the system.

4.1.2 Structural VAR Scheme

The second identification is based on sign and zero restrictions in order to disentangle the global shocks from the domestic ones. The smallest scheme consists of three domestic shock as well as foreign shocks. These aggregate domestic shocks are standard domestic shocks to identify the domestic economy. The fourth shock is for introducing a global monetary shock represented by effective Federal Reserve funds rate. The last one represents a positive Risk Premium shock. In that sceheme, instead of imposing the signs for longer horizons than the initial period, as the Uhlig (2005) paper did by leaving the US output level's response agnostic and identifying only one shock, I preferred to put the restrictions only on impact. First of all, the number of shocks in this research equals to the number of variables. Increasing the restrictions' horizons would definitely lower the acceptance rate to a great extent. Also, I only put the restrictions on the impact to see how the data speaks for the rest of the periods.

Table 4.2: **Initial Model Identification**

Shock/ variable	Domestic monetary	Domestic AS	Domestic AD	Foreign monetary	Risk Premium
Consumer prices	-	-	+	•	-
Real GDP	-	+	+	•	+
Policy rate	+	•	+	+	•
FED funds rate	0	0	0	+	•
Exchange rate	-	0	•	•	-

Notes: • = no restriction, + = positive sign, - = negative sign. All restrictions are imposed only on impact, the zero's denote the block exogeneity when the associated shocks are domestic ones due to the **block exogeneity** assumption. The exchange rate is defined as so that a **-** means an appreciation.

A positive *domestic aggregate supply shock* (hereafter the domestic AS) is the one that moves the real GDP and consumer prices in the opposite direction. Here, the source of the domestic supply shock can be thought of a positive total factor productivity (TFP) shock. Because there is no optimal monetary policy reaction to the supply shocks, the policy rate is left agnostic. In order to disentangle the domestic AS shock from a risk premium shock, the exchange rate is restricted not to respond in the first quarter in response to a domestic AS shock. These restrictions are rational signs with shocks related to domestic consumption and investment behaviors in New-Keynesian models documented such as by Smets and Wouters (2003).

A positive *domestic demand shock* moves both the real GDP and consumer prices in the same direction. Also, the response of the policy rate to a domestic aggregate demand (hereafter the domestic AD) shock is positive[2] (through the CBRT's reaction function).

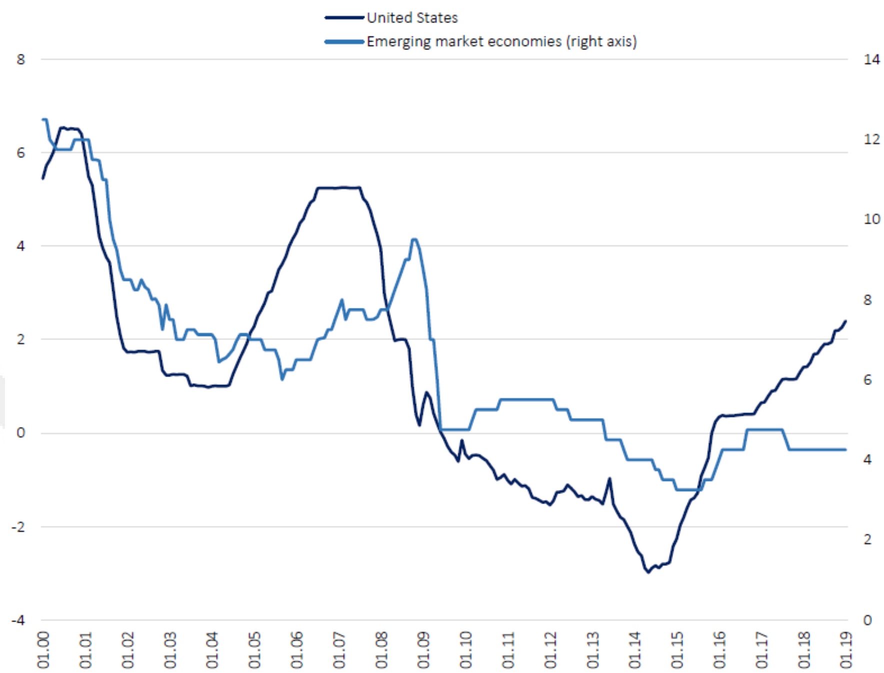
A positive *domestic monetary shock* is a standard contractionary monetary shock such that it decreases the consumer prices and real GDP while appreciating the exchange rate. For all domestic shocks, they have no impact on FED funds rate as expected in a small-open economy setting.

The *foreign monetary shock* is defined as a contractionary FED monetary shock that increases the effective federal funds rate. Hofmann and Takáts (2015) found that economically and statistically significant monetary spillovers from the United States to EM economies and there is an international interest rate co-movement in recent years despite business cycles' variation among countries. Their paper reported that a 100 bps change in the federal funds rate is associated with between a 26 bps to 46 bps shift in the policy rate of the EM economies. Likewise, in a 43 emerging and advanced economies in a panel setting, Caceres et al. (2016) have found that a 100 bps increase in US short term interest rates leads to a response of about 20 basis points in domestic short-term interest rates abroad. The Figure 4.2 shows that main policy rates of the emerging economies follow closely that of the US. The above-mentioned empirical studies point out that interest rates co-move across countries as the central banks respond to macroeconomic developments such as inflationary pressures due to supply or demand side channels, exchange rate issues and unemployment levels depending on their mandates. The Figure 4.3 demonstrated that although at some periods of time the relationship has weakened, there is an obvious positive co-movement between the Federal Reserve's effective funds rate and that of the Central Bank of the Republic of Turkey. As a small-open economy, Turkey is expected to follow the USA policy rate and thus, after a

[2] As a robustness check, I left the policy rate response to the domestic AD shock unrestricted and still there is a positive response of policy rate to that shock

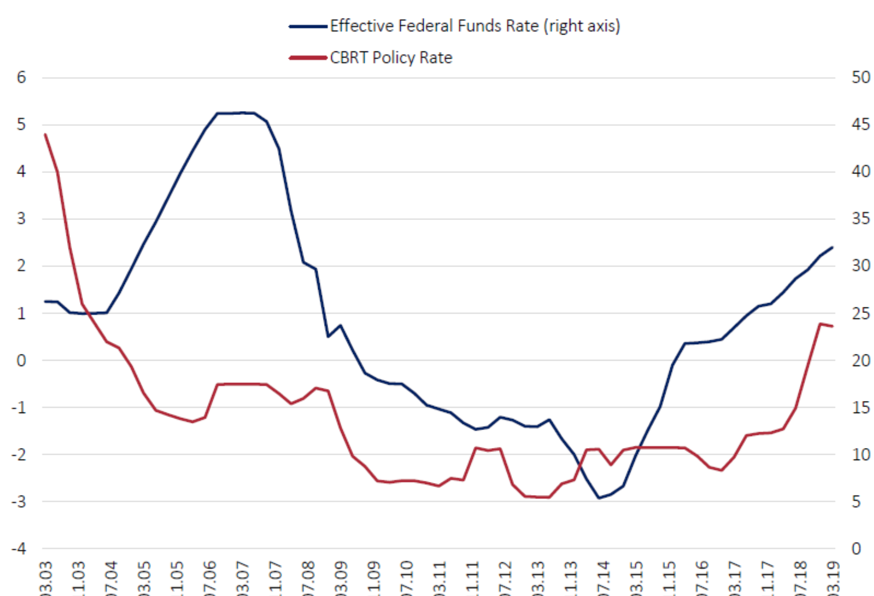
US monetary shock (a contractionary fed funds rate *ffr*), policy rate of the CBRT responds positively. Rest of the variables following this shock is left agnostic in order to let the data speak.

Figure 4.2: International Policy Interest Rates[1]



1 Median across Chili, Indonesia, Russia, Hungary, Mexico, India, South Africa, Brazil, Poland, Malaysia, Peru, Columbia, Romania and Turkey, where data are available. Source: BIS Statistics, Wu-Xia(2015) shadow rates.

Figure 4.3: Effective FED funds rate and CBRT Policy Rates



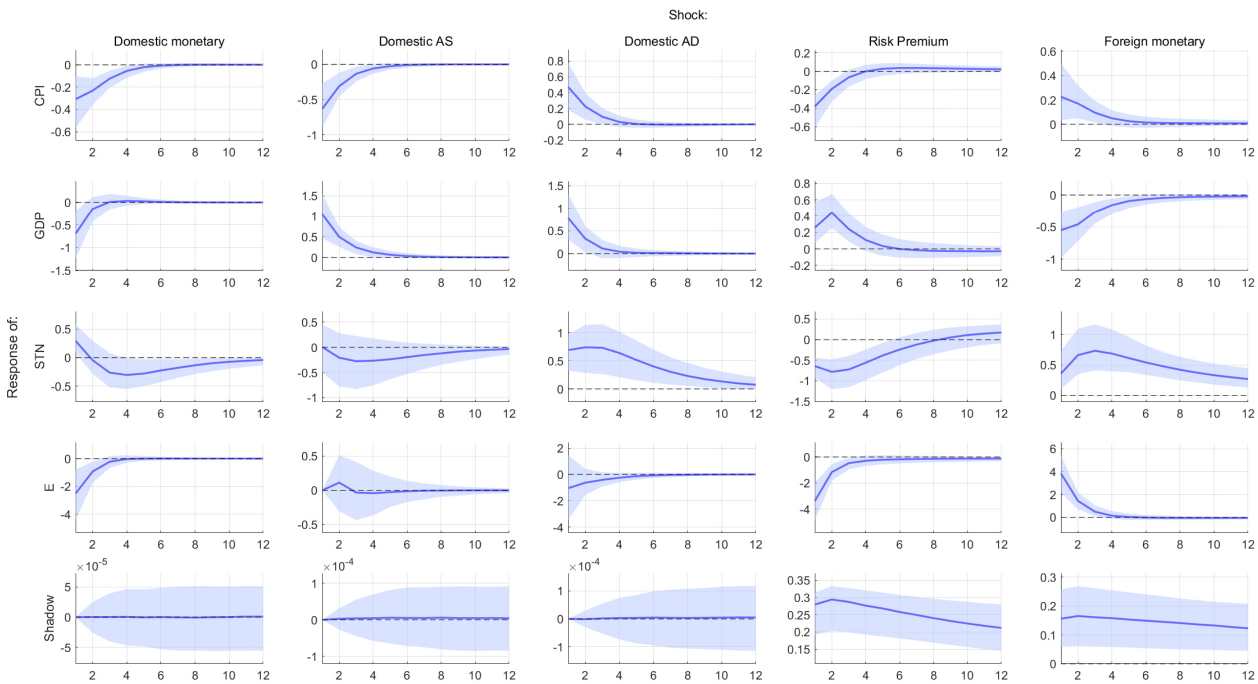
Source: FRED Economic Data, CBRT, Bloomberg

The last one is a risk premium shock. It acts as a positive risk premium factor for an emerging market such that it lowers the consumer prices, increases the output level while appreciating the exchange rate. I did not leave FED funds rate restricted to a risk premium shock as it is considered as a positive risk premium shock to an emerging economy while depreciating the US dollar. Therefore, Federal Reserve may (or may not) respond to this negative exchange rate shock directed to its currency. With these signs all of the shocks in the structural system are identified and disentangled from each other. The priors and the hyperparameters chosen for the baseline scheme are as follows:

- In the estimations, Minnesota prior is preferred. Moreover, trials with an Independent Normal Wishart prior yielded quite similar results to those of the Minnesota prior results, therefore the choice of the prior in the estimations are robust to different priors.
- The hyperparameters are as follows (the values are chosen according to the Grid Search procedure of the (Giannone et al., 2015) that maximizes the marginal likelihood of the model). During the estimations, 5000 iterations are carried out while the first 1000 of which are used as a burn-in sample.
  - AR coeffient: 0.7
  - Overall tightness (λ_1) = 0.1
  - Cross-variable weighting (λ_2) = 1
  - Lag decay (λ_3) = 1
  - Exogeneous variable tightness (λ_4) = 100

The impulse-responses are as follows for the baseline model.

Figure 4.4: **Initial Model's Impulse-Responses**



Note: The dark blue line represents the median of the posterior distribution. The shaded light blue area is the 0.68 probability interval of the posterior distribution. STN is the CBRT policy rate variable.

The **domestic monetary policy shock** satisfies all the imposed restrictions as can be seen from the Figure 4.4. Following a domestic monetary contraction (of 300 bps hike), the price level and output responds in opposite directions with quite narrow credibility bands, as well as a significant appreciation of the Turkish lira. Here, it is obvious that the commonly observed puzzles are resolved with a structurally identified shocks. One thing to note here is that, the shaded areas should not be interpreted as confidence bands/intervals as conventionally done in a traditional VAR models estimated with OLS. The bands in the SVAR models are the Bayesian credibility intervals showing the 16^{th} and 84^{th} percentiles of the accepted draws from the posterior distributions. As a small-open economy, Turkey's monetary policy has no impact on that of USA and a downward skewed exchange rate appreciation is obvious, as expected.

Regarding the **domestic AS shock**, it decreases the price level and increases the output. The agnostic variables for the domestic AS shocks are the exchange rate and the policy rate. It is observed that monetary policy is accommodated in case of a domestic supply shock. The explanation for this is as follows: a domestic AS shock can be considered as a positive TFP shock. It causes the real GDP level to rise and price levels to fall.

In case of a **domestic AD shock**, the price level and output moves in opposite directions and as an optimal reaction to that the policy rate is increased. Following that, the exchange rate shows a limited appreciation, although much of an insignificant type but still skewed to downward direction verifiying an appreciation.

It is generally found as an empirical evidence in the literature that, after a **US monetary contraction**, the exchange rates of the emerging markets follow a significant depreciation (Gupta et al., 2017). Turkish lira was not an exception. It depreciated around 3.8 percent on impact after a 155 bps FED hike. Following a global monetary shock, The CBRT increases its policy rate, around 360 bps, more than the Federal Reserve increases its main policy rate. As a consequence, there is 0.55 percentage points contraction in the real GDP. What we see is that, after a FED policy rate rise, the Turkey follows it and significant price level rise occurs (around 0.22 percentage points) as well as a fall in real GDP. These results are in line with other studies focusing on the international spillovers of US monetary policy such as Maćkowiak (2007), Caceres et al. (2016), Demir (2019) where they find a contraction in real GDP and a rise in interest rates after a US monetary contraction. In case of the **positive risk premium shock**, the prive level falls and output shows a hump-shaped behavior and rises up to first 2 quarters then starts to fall as the US monetary policy rate is increased too. Because in case of a risk premium fall for EM countries, in order to preserve the value of the US dollar, a contractionary stance is observed in US monetary policy, which makes sense considering the positive RP shock as a negative development for the US dollar.

The crucial thing regarding the identification of the macroeconomic shocks of the Initial Model in here is that identifying only the US monetary shock (and the Risk Premium shock) as a global shock though a full set of standard domestic shocks exist, does not seem to be sufficient enough to capture the structural disturbances relevant for a small-open economy. The line of reasoning is as follows:

1. Whether the FED responds to its domestic demand conditions,
2. or it responds to the global supply or demand conditions driven by the oil market developments or global real activity is unclear.
3. Global aggregate supply and global aggregate demand shocks are needed in order to complete and close the system in a macroeconomic modelling perspective.

Due to the abovementioned reasons, adding two more shocks into the system in order to better identify the relevant external shocks for a small open economy is presented in the Baseline model.

4.2 Baseline Model

Adding additional **global aggregate supply** and **global aggregate demand** shocks will complete the system in a macroeconomic framework and thus enable me to identify both domestic monetary, supply and demand shocks with global counterparts of each component related to Turkey as an emerging economy. Global AD shock is thought as a standard demand shock in accordance with a positive change in global real activity while global AS shock will operate in the system as a negative oil supply shock which contracts the overall economic activity in the world. Therefore, the macroeconomic aggregates in Turkey as an emerging economy will be fully identified with the associated macro-shocks by this approach.

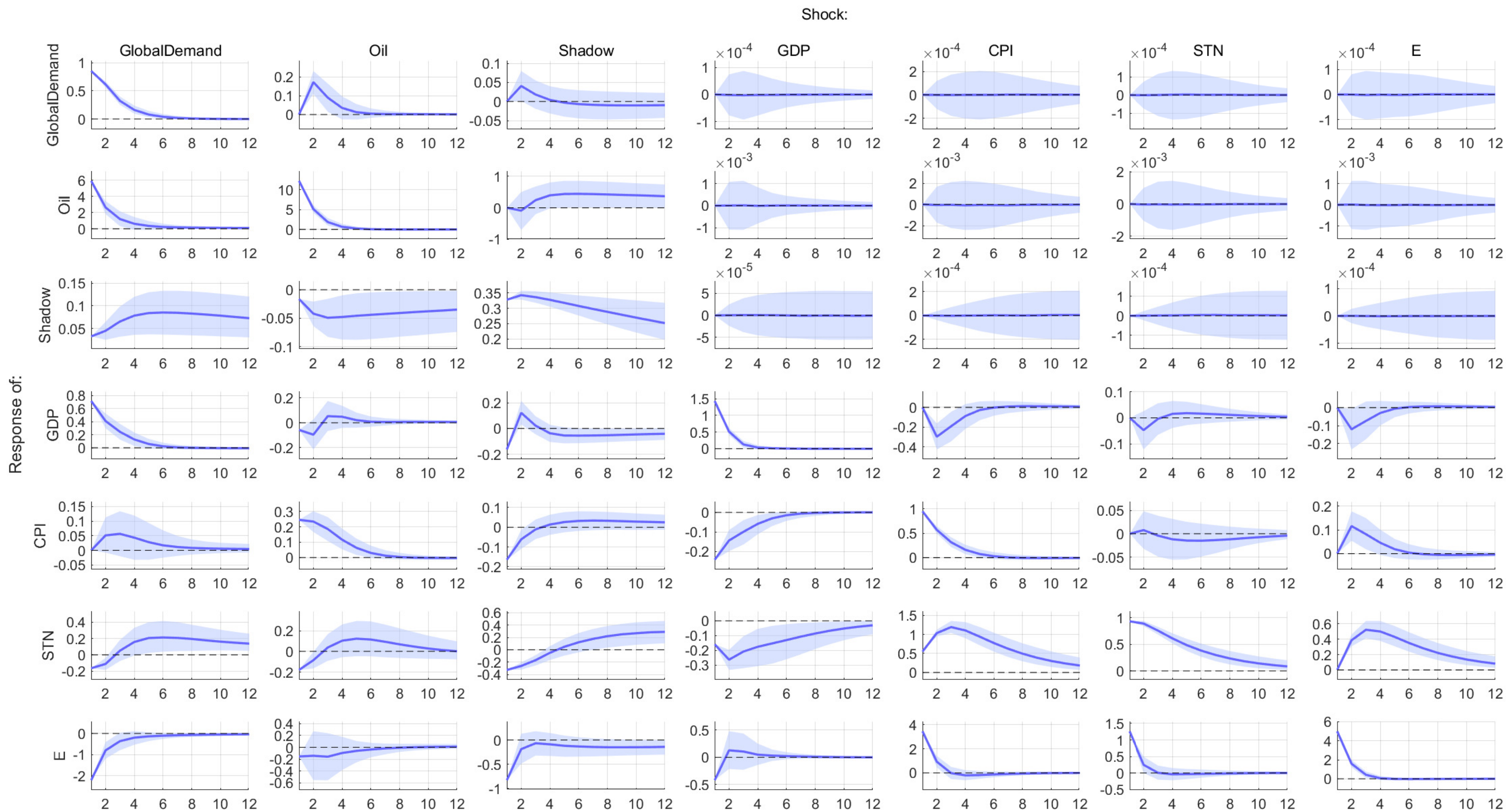
4.2.1 Cholesky Scheme

The ordering in the recursively identified system has been chosen as follows: global real activity, price of oil in US dollars, the FED funds rate, the domestic output, consumer prices and the policy rate of Turkey, and the bilateral, USD/TL exchange rate. The foreign block of variables has been ordering in itself according to the suggestions of Kilian and Zhou (2019). The main arguments for this argument is that the as Kilian and Vega (2011) have tested the assumption of the oil prices are predetermined with respect to US macroeconomic news at a monthly frequency. They found no evidence of feedback relation between US variables and oil prices, contradicting the view that energy prices respond instantaneously to macroeconomic news. Moreover, the global demand variable is placed at the first ordered variable because the global business cycles shape the fluctuations in oil prices and the US monetary policy stance to a great extent, either in a direct or an indirect way (Kilian, 2009; Anzuini et al., 2012; Kilian and Zhou, 2019).

The argument advocated by Bernanke et al. (1997) (BGW) that the Federal Reserve responds to the inflationary pressures caused by the oil price shocks and thus created a global slowdown in growth dynamics has been challenged by the Kilian and Lewis (2011). The latter found no credible evidence that monetary policy responses to oil price shocks caused large aggregate fluctuations recently. Moreover, the authors postulated that the traditional arguments of the BGW should be replaced by models taking into account of the endogeneity of the oil price and allowing for the underlying causes of the oil price shocks. Thus, it is valid to place the oil price variable before the US policy rate variable to account for this credible finding in the literature. Moreover, in accordance with the evidence by the Kilian and Vega (2011), it is advisable to not to put oil price after the FED funds rate variable in recursive systems. In the Baseline model, following the advices of Kilian and Lewis (2011), I allowed the endogeneity of the oil prices and identify the possible underlying shocks deriving the price of oil. Therefore, in the structural vAR version of the Baseline Model presented in Section 4.2.2, because I disentangle the supply and demand shocks in the global economy, price of oil as a commodity good is allowed to be affected by the US monetary policy stance, in line with the findings of Anzuini et al. (2013).

The domestic block is ordered *inter se*, following the traditional approach in the empirical-macro literature: after the foreign variables followed by the domestic output, consumer prices, policy rate and the exchange rate order.

Figure 4.5: **Cholesky Identification Results**



What is apparent from the Cholesky scheme of the Baseline model is that, after a domestic monetary shock (a rise in CBRT policy rate), the exchange rate depreciates. This is again one example of an exchange rate puzzle that the recursive scheme fails to solve.

4.2.2 Structural VAR Scheme

Firstly, I add a global demand shock to partial out a possible reaction of FED monetary authorities to the global demand conditions. However it turned out as an insufficient improvement, as a global supply shock is needed to be able to disentangle a candidate global AD shock from a global AS shock with regards to the identification. Both global supply and demand shocks are included simultaneously to assess how the emerging market economy in concern responds to each shock. The identification scheme regarding the full model is as follows:

Table 4.3: **Baseline Model Identification**

Shock / variable	Domestic Monetary	Domestic Aggregate Supply	Domestic Aggregate Demand	Risk Premium	Global Aggregate Demand	Global Aggregate Supply	Foreign Monetary
Consumer prices	-	-	+	-	+	+	•
Real GDP	-	+	+	+	+	•	•
Policy rate	+	•	+	•	•	•	+
Exchange rate	-	0	•	-	•	•	•
Global Demand	0	0	0	0	+	-	•
Oil Price	0	0	0	0	+	+	•
FED funds rate	0	0	0	•	•	0	+

Notes: • = no restriction, + = positive sign, - = negative sign. All restrictions are imposed only on impact, the zero's denote the block exogeneity when the associated shocks are domestic ones due to the **block exogeneity** assumption. The exchange rate is defined as so that a **-** means an appreciation.

The usual domestic supply, demand and monetary shocks as well as the effective FED funds rate shocks are channelled into the system as explained in previous subsections. The same prior and the hyperparameters are preferred as employed in the Initial model. The block exogeneity feature is preserved, too. The strategy for identification in this Full Model mostly follows the logic of Conti et al. (2017) and Jarocinski and Bobeica (2017). Identification of the global shocks is as follows[3] :

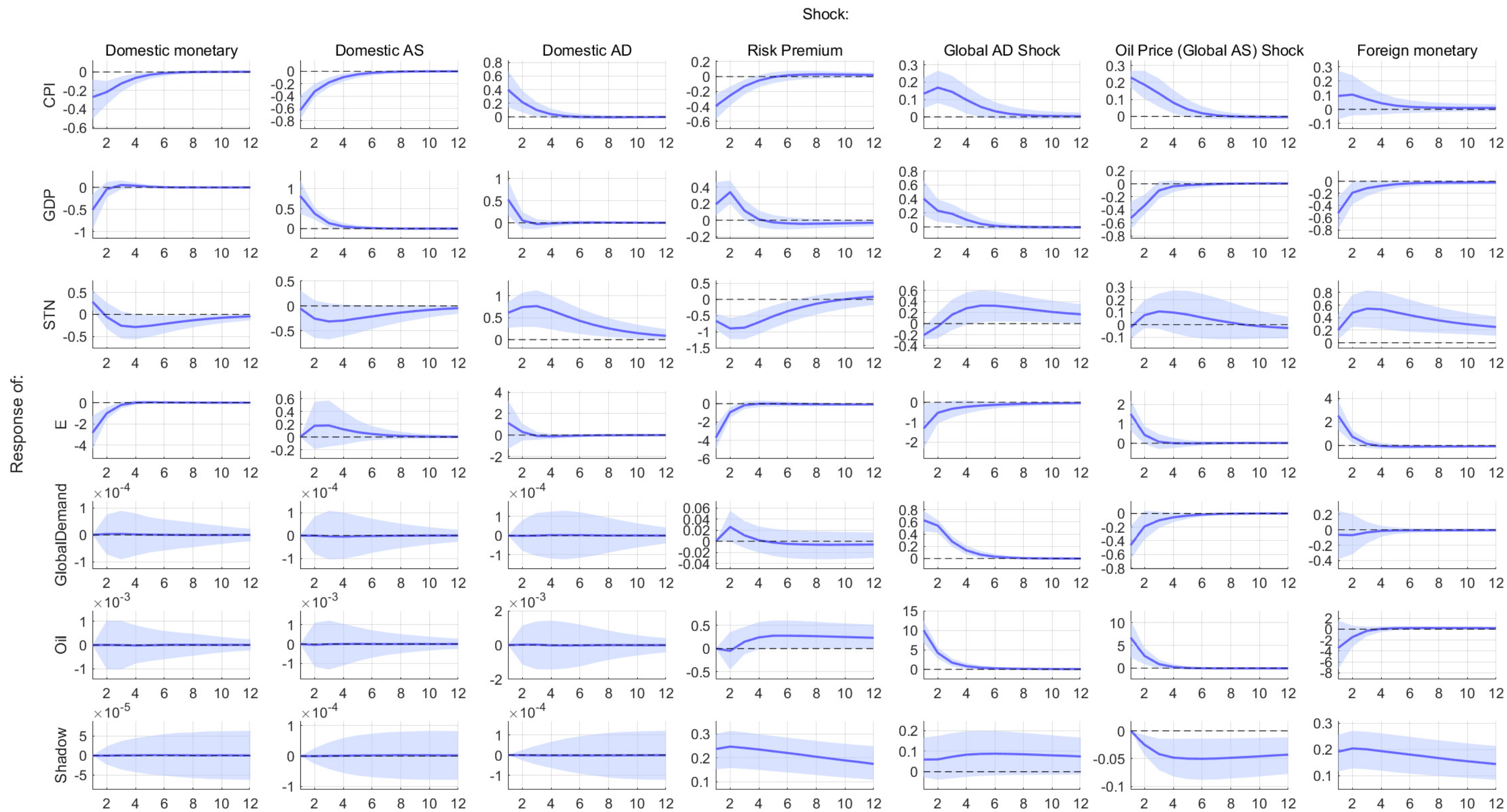
The standard oil price shock is assumed to be a negative global aggregate supply shock. An exogenous increase in the real price of oil causes price level to rise and it decreases the foreign output. With the fall in global demand, global supply shock is disentangled from the global demand. The response of output level of Turkey to a negative oil supply shock is left unrestricted because of the following: Output level of Turkey may fall down as the global economic activity contracts due to the positive oil price shock. On the other hand, because of higher oil prices, the export partners' of Turkey that are oil exporters (such as the OPEC members) can experience a positive wealth effect and this could generate increased exports for Turkey and may imply an output level rise for Turkey, too. Thus, I prefer to leave the response of the real GDP of Turkey to the positive oil price shock agnostic and let the data speak about the response behavior to observe which channel dominates more. I did not impose any restriction on the policy rate (following other studies such as, Peersman and van Robays (2009)) as there is no optimal response of monetary authorities to an oil supply shock (like there is no optimal monetary response to domestic aggregate supply shocks). Because the oil price shocks imply both an inflationary pressure and a possible output contraction for the economy (Conti et al., 2017), central banks do, at least, try to not to respond temporary oil price fluctuations (Jarocinski and Bobeica, 2017) until it generates a strong distorting mechanism on pricing behavior. For this line of reasoning, I put a zero restriction on the first period response of US monetary policy to a global AS shock so as to limit an immediate reaction of the Federal funds rate to an oil price shock.

A positive **global demand shock** is assumed to create a positive co-movement between the price of oil and the global economic activity. The identification of this shock is important because it disentangles a positive domestic demand shock from that of a globally originated one. Here, it is assumed that following a global demand shock, there is a rise in the oil prices due to demand-side pressure to the commodity prices as oil is used both for consumption and production. On the other hand, a positive **domestic demand shock** increases both the consumer prices and the real GDP while not affecting the oil price, global demand and FED

[3]Certain related studies (Corsetti et al., 2014; Conti et al., 2017; Jovičić and Kunovac, 2017) include a variable as the share of domestic real GDP in the world output and separate global and domestic nature of aggregate demand shocks by imposing opposite signs after a domestically and globally originated demand shocks. However, in order not to increase the number of variables due to sample size being small and to avoid the overparametrization issue, I did not prefer to follow that approach.

funds rate as foreign variables are kept exogeneous to domestic ones. The Grid Search procedure yielded the same hyperparameters for the coefficient terms and the variance-covariance matrices. The resulting IRF for the identified shocks in the system is as follows:

Figure 4.6: **Baseline Model's Impulse-Responses**



The domestic block, their shocks and the responses are as expected and as in the Initial model's IRF (see the Figure 4.4). The external block yield the following:

The foreign monetary shock:

Following a US monetary policy contraction of 20 bps, there is an obvious interest rate rise in Turkey around 20 bps, too. The above Figure 4.6 depicts a strong response from the Turkish policy rate on impact and for over two years as the whole portion of the credibility band stays above the zero line for all of the periods. Turkish lira depreciates, around 2.5 percentage points on impact and this downward trend continues to hold significantly for three quarters after the foreign monetary shock initializes. The domestic output level demonstrates a 0.5 percent immediate decline on impact. In terms of the contractionary impact of an US monetary tightening, the domestic demand has weakened. The explanation for that is the contraction in the US demand following the monetary tightening spills over internationally to both advanced and emerging economies with a similar contraction in their real economies (as found by MacDonald and Popiel (2017), Canova (2005), Maćkowiak (2007), among many). This negative response can at the same time be attributed to the rise in policy rate in the domestic economy and its contractionary impact on the real economy. The domestic price level also demonstrates a significant response, around 0.10 inflationary pressures that is similar to the finding in the baseline model in which only the foreign monetary shock is introduced in the SVAR.

In short, the contractionary US monetary policy causes a contagion effect on interest rates of Turkey, as a follower, small open economy [4] For the agnostic variables in the domestic block (GDP, CPI and Exchange rate), except for the price level, it is observed that significant responses on impact with nearly narrow credibility bands materialize. With regards to being agnostic, the problem here may have arised that unrestricted responses are always randomly rotated without any restrictions. Thus, this random rotation almost systematically results

[4] One may argue that in the sign restriction approach, the restricted variables naturally satisfy the imposed sign and thus have the desired shape in IRFs. This argument is only partially true, because still having a significant credibility bands along with the desired sign and having more of the portion of the band above/below the zero line is an important result to achieve in terms of the sign restriction approach in the SVAR literature. The way the algorithm works is as follows: it generates the impulse response functions from the reduced-form VAR, then implements a random rotation of those IRFs, then checks whether the conditions are satisfied. If yes, the new IRFs are retained, if not, a new attempt is made until the pre-imposed acceptance is obtained. Because, unless, a magnitude restrictions are imposed, a positive 100 percent and a positive 1 percent are equal in terms of the sign restriction approach. As the credibility bands are the summary information about the distribution of the total IRFs which are accepted by their sign, although restricted, the response of a variable satisfying the imposed sign is important and the bandwidth of the IRFs can not be interpreted as standard confidence intervals logic.

in IRFs being more or less flat when averaged over the draws. Therefore, not having flat IRFs in case of agnostically left variables is a significantly valuable outcome in terms of the identification.

After a US monetary contraction the global demand variable does not respond significantly as can be noticed with a flat IRF which seemed an interesting result. This can be due to the fact that because the global AD and the foreign moneary shocks are orthogonal to eachother, FED may have responded to its own demand conditions, so that the global demand to FED monetary shock does not show any responsive pattern. The crude oil price declines around 3.4 percentage points after a 20 bps hike in FFR. According to Anzuini et al. (2012) who documented the empirical relationship between the US monetary policy and the commodity prices, it is found out that there has been a significant relationship among these. In line with the results of the seminal papers about the oil prices and the macroeconomy (Barsky and Kilian, 2004, 2001), the above findings points out evidence that the monetary policy is a significant predictor of the commodity prices. These studies reported that the impact of the monetary policy is deemed to transmit into commodity prices via the expected growth and inflation channels rather than the oil supply, oil inventories and the financial market channels. The study of Anzuini et al. (2012) reported that 100 bps US monetary easing results in approximately 3% and 1% percent increase in commodity price index and oil price in particular, respectively. The SVAR results of the Baseline Model employed in my paper verifies this inversely related mechanism between the price of oil and the US monetary shock. Considering the price of oil and the exchange rate yields a similar argument as well. As the US dollar appreciates, the oil price falls down as it is priced in US dollar terms. Likewise, because the oil production rises after a US interest rates rise as the opportunity cost of keeping oil reserves on the ground rises, a fall in oil prices is an anticipated reaction. What is is crucial to stress that FED monetary shock is a contractionary foreign monetary shock such that it is orthogonal to the all other shocks identified in the VAR system, that is, it's the impact of all other surprise FED monetary shock after controlling for the impact of a positive oil price (global aggregate supply shock) and a positive global demand shock. Historically, the price of oil and the price of US dollar is inversely related[5]. Therefore, this inverse relationship is verified in the IRFs as well.

Global aggregate supply shock:

[5] The idea is based on the premise that in case of an appreciating US dollar, one needs fewer USD for a barrel of crude oil

Negative global aggregate supply shock has been defined by its impact on rising oil prices and domestic price level. In case of an oil price shock with which there is a fall in the global demand, the FED does not respond initially but then it loosens its monetary stance gradually. On impact, exchange rate depreciates but after two quarters, it reverts back to its original course. It is apparent that the CBRT does not respond to a rise in the oil prices originated as a global AS shock which is in line with our expectations as the central banks do not, at least try to, respond to fluctuations in the commodity prices at the first place and no optimal response exists in the standard macro-literature. With a high credibility band of the posterior draws and approximately a flat response of CBRT policy rate to oil supply shock justify this presupposition. The consumer prices in Turkey rises following the oil price shock which makes sense considering both the exchange rate pass through to prices and the rising input prices (as oil is used both for consumption and production process) creates additional cost burden for the producers. When the response of real output is examined, a fall in real GDP is significant. This can be due to the fall in global demand conditions caused by the negative supply side factors because there is no room for contractionary impact of CBRT's policy stance as no response is observed at the policy rate. We can say confidently that the export partners' income rise via an increased oil price shock does not channel into the system, rather, the global demand contraction channel works more predominantly. Cashin et al. (2014) reported that oil importers typically face a long-lived fall in economic activity in response to a supply-driven surge in oil prices, that is parallel to the above results.

Global aggregate demand shock:

What is left agnostic in case of the global AD shock is domestic policy rate, FED Funds rate and exchange rate. After a positive global demand shock, Federal Reserve responds positively and significantly while there is negative but not much significant response from the CBRT on impact. Only after 2 to 3 quarters, a positive and significant response of the policy rate is detected. Exchange rate appreciated on impact around 1.3 percent but then normalizes to its original path after five quarters. From the Figure 4.6, we observe that the central bank of Turkey does not respond to the oil price movements and thus the supply side shocks, as anticipated, but it reacts significantly to the developments in the global demand after observing certain temporary inflationary pressures are realized.

On the basis of the Baseline model, the related Historical Decomposition and the Forecast Error Variance Decomposition are presented in the Appendix C. According to the FEVD analysis, most of the variance in the CBRT policy rate is due to the global shocks, especially as the forecast horizon expands. Also the role of the domestic aggregate demand is non-negligible. It is obvious that for the domestic output level the foreign monetary shock has more role than an oil price, global demand and a risk premium shock, while for the price level the situation is vice versa as the risk premium shocks make up most of the variation while forecasting the price levels. In case of the exchange rate, for all of the horizons, the sum of the global shocks makes up almost the total variation. One can infer from the FEVD graph that while for the macro variables, the sum of the global shocks have equal weight with that of the domestic ones. However, for the exchange rate the CBRT policy rate, it is clear that the global shocks dominates the domestically originated disturbances in the economy. Therefore, it is not a surprising consequence that financial variables are more exposed to the variations in the global shocks than the real variables are.

When the historical decomposition plots are analysed, the fluctuations in the global demand is mainly due to the global aggregate demand shocks in the world. One can observe that the foreign monetary shocks and the oil price shocks play quite a little part in the global demand historically. For the Federal Reserve funds rate, it is mostly driven by the US monetary shock itself as well as the risk premium shocks in the global economy. Because the risk premium shock reflects all the shocks that depreciate the US dollar while lowering (increasing) the domestic price (output) level besides the global supply, global demand and the foreign monetary shock, it makes sense that FED takes action according the the value of the US dollar. When the changes in the oil price are examined, the most dominant factor is obviously the global demand. The model results supports the findings of Kilian (2009) that historically, the decompositions of the fluctuations in the price of oil have been driven by a combination of global aggregate demand shoks and precautinary demand shocks for oil, rather than supply of the oil itself. Historical decomposition of the oil prices reveals that foreign monetary shocks have little contribution in the price of oil.

Regarding the domestic variables, most of the policy rate of CBRT is determined primarily by risk premium, foreign monetary and domestic aggregate demand shocks to a lesser extent. Therefore, it can be confidently said that the CBRT takes into account of the global developments while forming its monetary stance, as a small open economy. Especially the recent developments in the bilateral exchange rate suggest that the risk premium, oil prices and the US monetary shock have played the greatest role. When it comes to the price level fluctuations, the recent surge in the inflation rate are fundamentally caused by domestic demand and risk premium shocks. The oil price shocks contributed more to the consumer price fluctuations less than it did to the exchange rate. When the output level is taken into consideration, the recent fall in the Turkish real GDP can be explained by a risk premium shock and a negative aggregate supply shock. In this period, the aggregate domestic and global demand limited the contraction in real GDP.

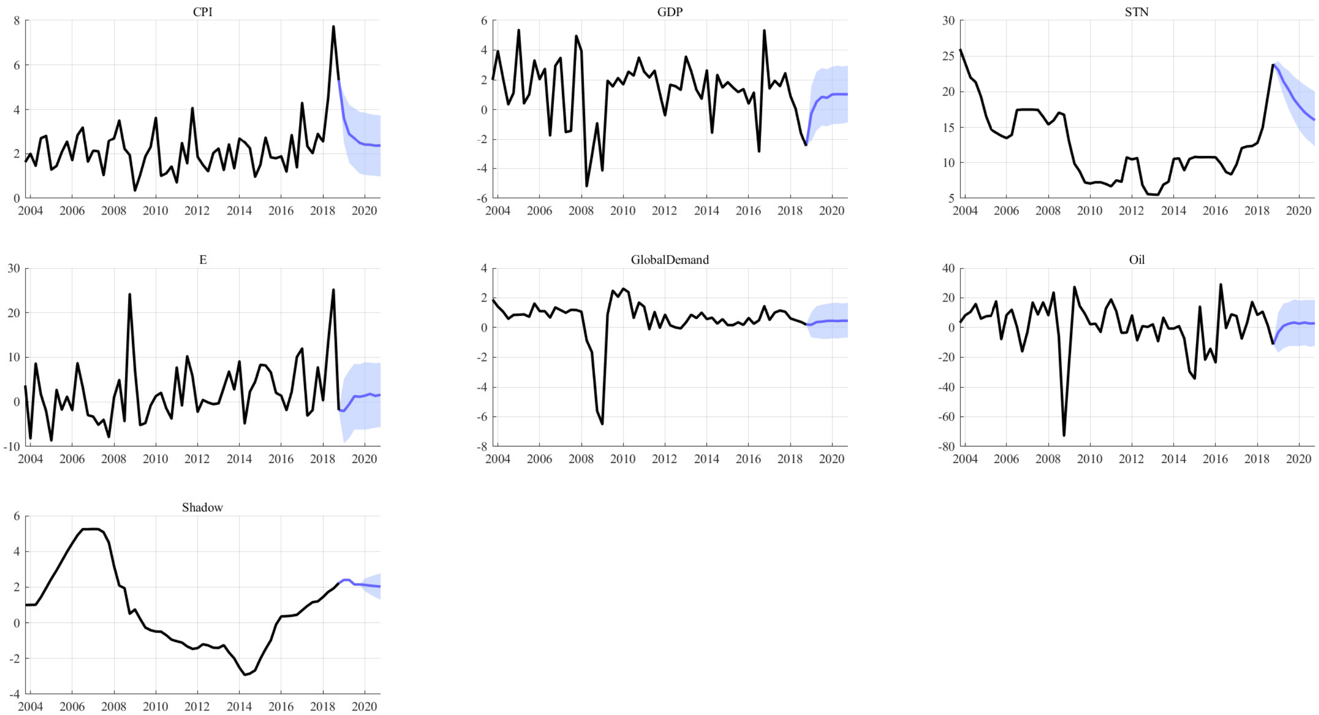
The FEVD plots, on the other hand, proves that the foreign monetary shock explains most of the variance in the USD/TL exchange rate and the policy rate of CBRT. Interestingly, the sum of all the domestic shocks make up a little more than the global shocks while explaining the variance of the output level of Turkey. However, for the price level, policy rate and the exchange rate, the foreign shocks contribute more than the domestic shocks in all of the periods, and in particular, to an expanding extent as the forecast horizon increases. For the oil price, the global demand shocks determine the most of the variance, while the fluctuations of the foreign monetary shock itself and the risk premium explains the variance in the FED funds rate.

4.3 A Conditional Forecasting Exercise

Since the primary concern is how the US monetary policy shape the global markets, as a scenario analysis, based on the market expectations and the minutes of the Governor of the FED, two consecutive monetary loosening of 25 bps each is anticipated by the markets during the second half of the 2019 because of the low inflationary period, the fear of a global slowdown and trade flows due to the ongoing global trade war issues between the United States and China. In the July meeting of FED, a monetary loosening is a quite likely move by the Federal Reserve while considering the current conjuncture. Following these assumptions, here is a conditional forecast results for the period 2019:II to 2020:IV, after imposing a 25 bps decrease in the effective FED funds rate for the two quarters for the second hald of the 2019, while leaving no conditions for the rest of the shocks and using the realized first two quarters of 2019 values of the FED funds rate. In this conditional forecasting exercise, all the shocks are included in the model to generate the forecasts. By using the all shocks methodology, it implies that one is certain that all of the shocks will contribute to generate the conditions, which is a plausible and informative assumption as the shocks in my model are the key cornerstone structural shocks driving the domestic and the global economy.

After a foreign monetary easing valid for the period second half of 2019, the results imply a significant easing in the CBRT policy rate, a fall in the consumer price level, a relatively stable exchange rate and an upward trend in the real domestic output throughout the 2020. Likewise, following the US monetary tightening, a positive outlook is expected for the global production, while the oil prices are expected to rise.

Figure 4.7: **Loosening FED Funds Rate Scenario**



Section 5

Robustness Testing

In this part by employing alternative variable choices in the structural vector auto-regressions and by replacing one by one the related variables in the following subsections with their alternatives, he Baseline model's data sensitivity is tested.

5.1 Alternative Shadow Rate

As a robustness check, shadow rate alternatives are tried and an alternative shadow rate also yielded the similar robust results. Since the large portion of the estimation period corresponds to a period at which the Federal Reserve engaged in unconventional monetary policy actions in order to stimulate the economy by lowering the long-term interest rates (i.e. the quantitative easing period), the choice of the shadow rates in the estimation is important. There are alternative shadow rates published by various researchers besides the shadow US federal funds rate by Wu and Xia (2016) which is adopted in this study. Below is the estimation results of the quarterly SVAR models by employing the Shadow US interest rates generated by an option-pricing model of the Krippner (2013). The structural scheme of the SVAR model is not changed for both the Initial (at Figures 5.1 and 5.2) and the Baseline model (at Figures 5.3 and 5.4) estimation.

Figure 5.1: **Initial Model, Cholesky**

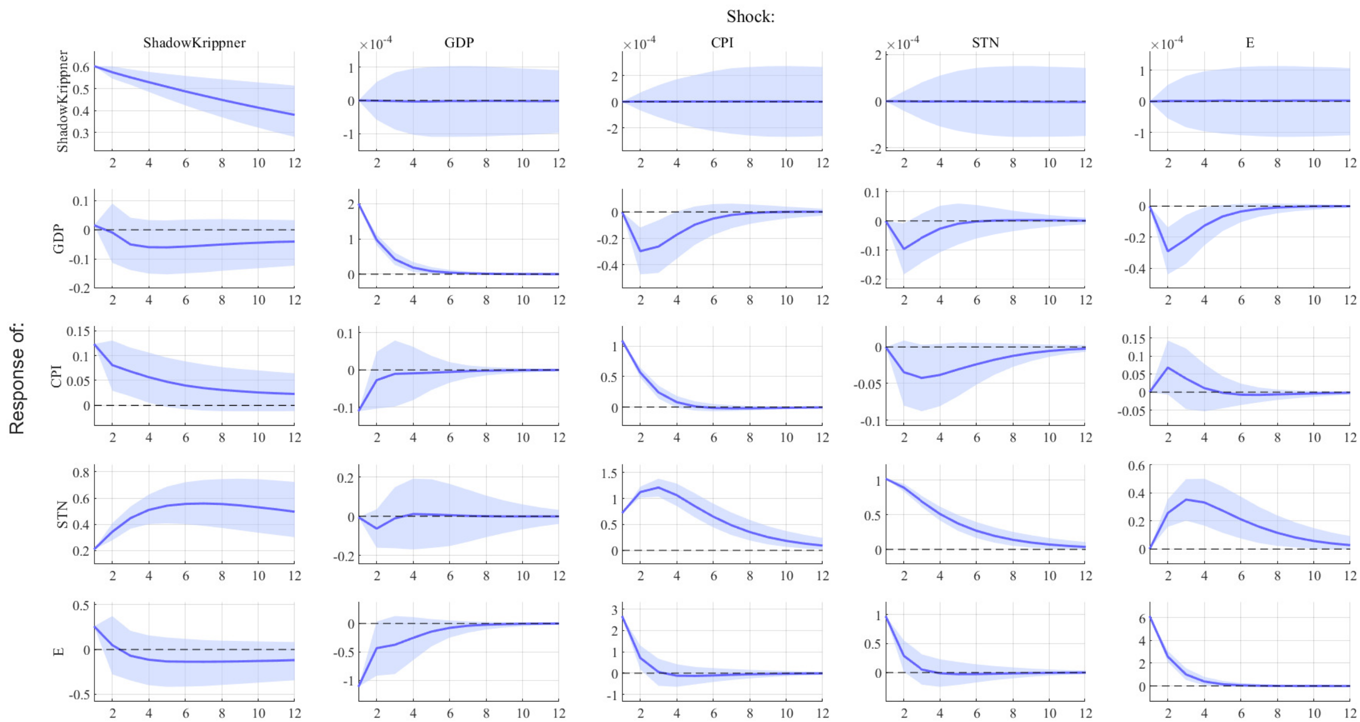


Figure 5.2: **Initial Model, SVAR**

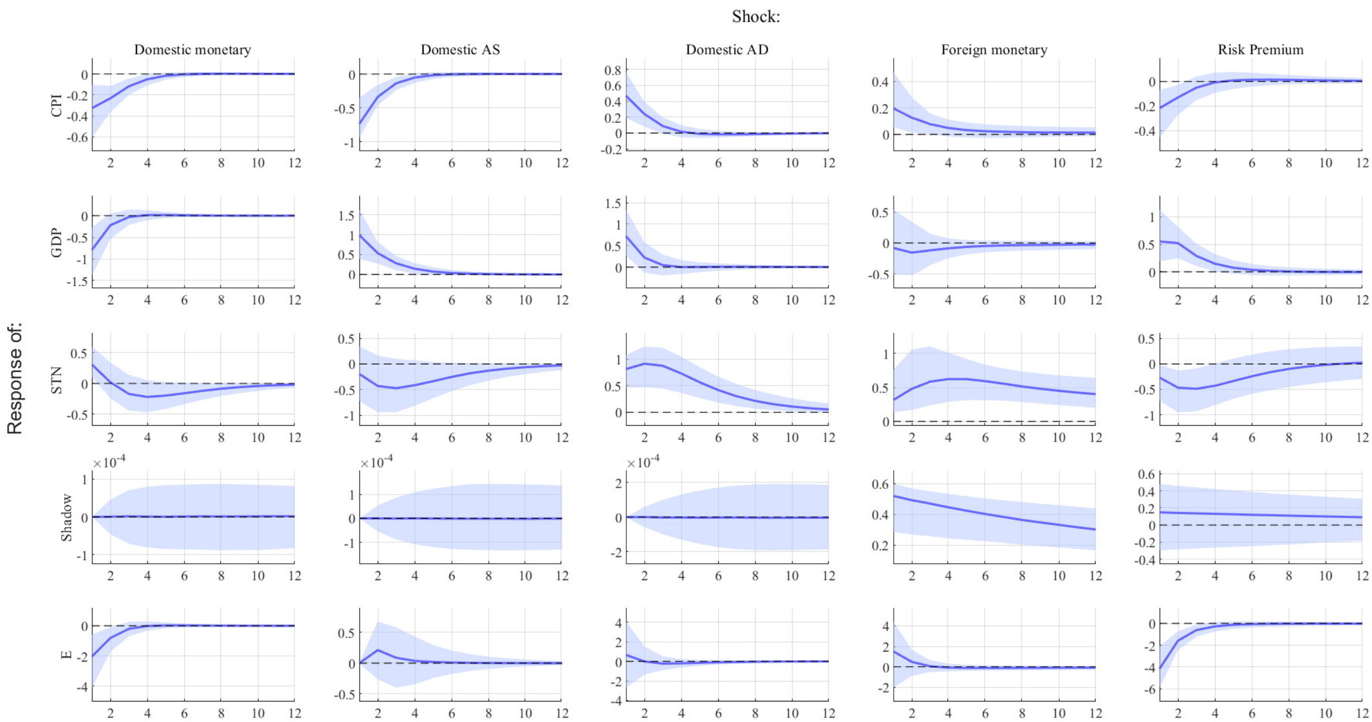


Figure 5.3: **Baseline Model, Cholesky**

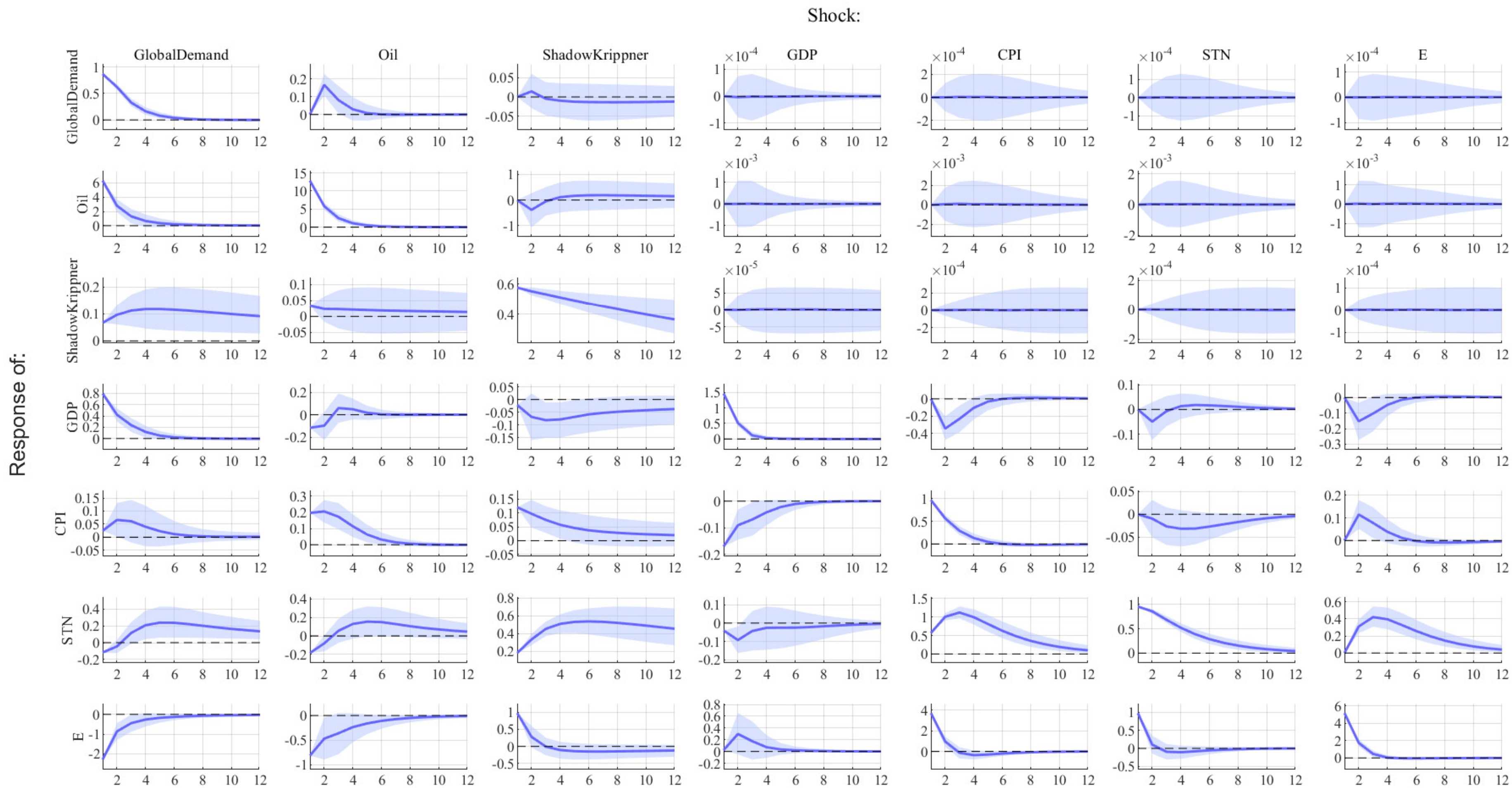
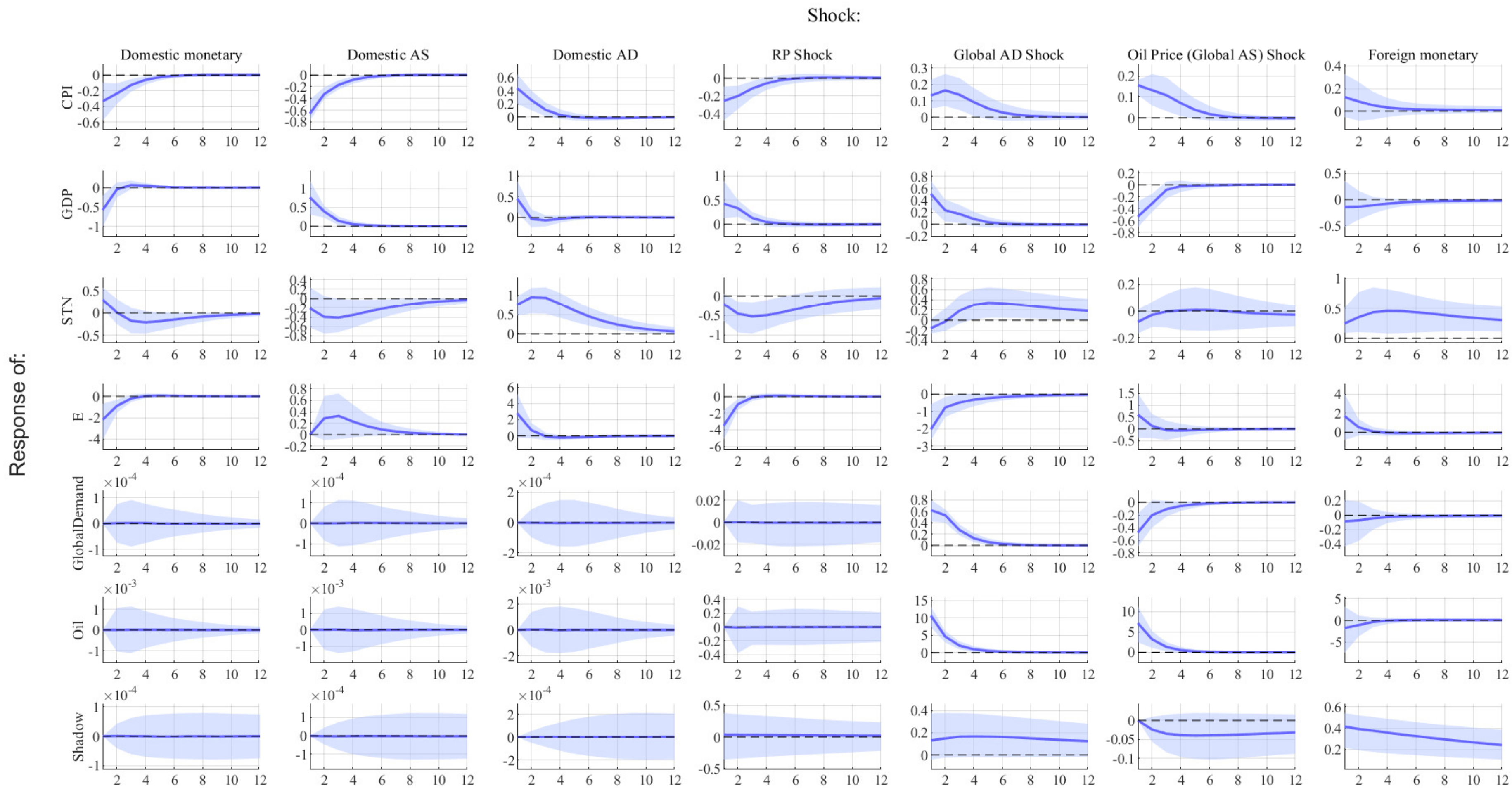


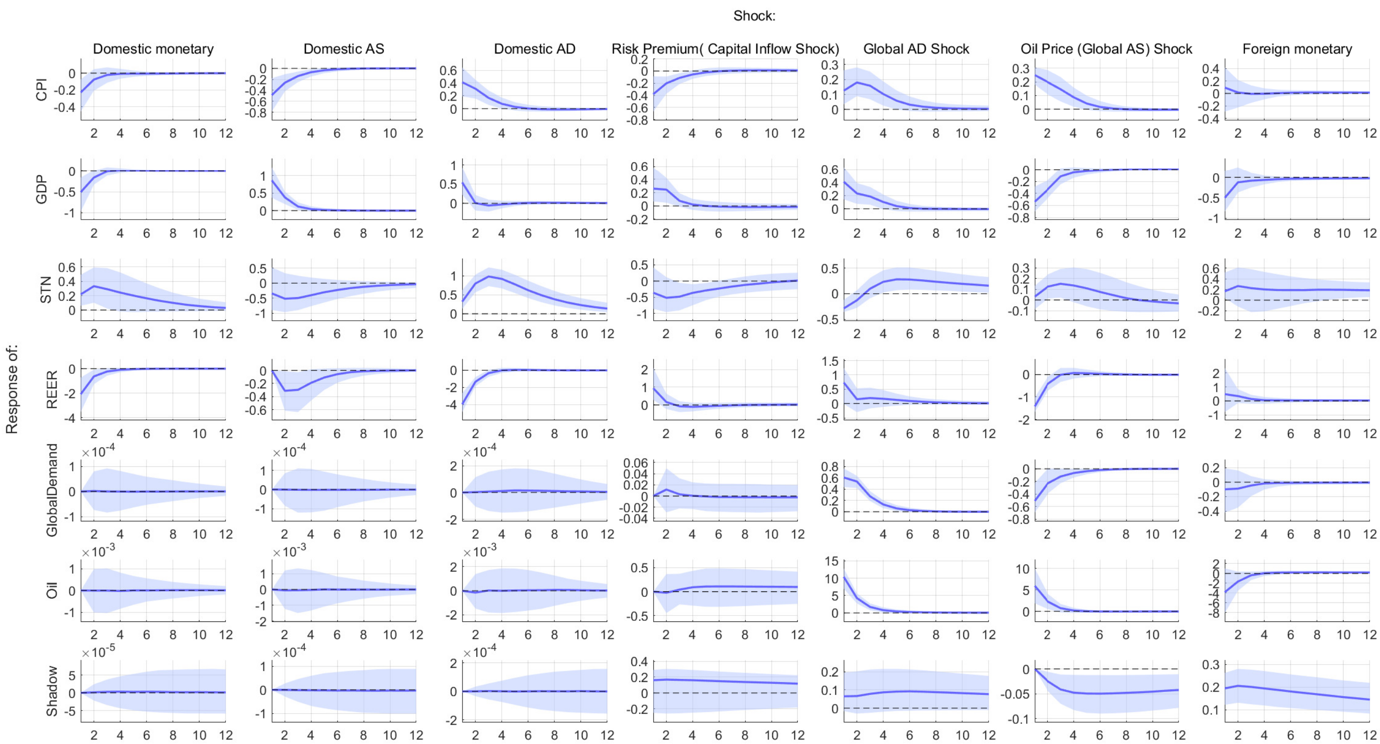
Figure 5.4: **Baseline Model, SVAR**



5.2 Using Real Effective Exchange Rate

Instead of using the bilateral USD/TL exchange rate, the Real Effective Exchange Rate (REER) comprising 60 countries, published by BIS Statistics Database is used as an alternative indicator for the exchange rate of Turkey. The results are robust to this alternative and as follows:

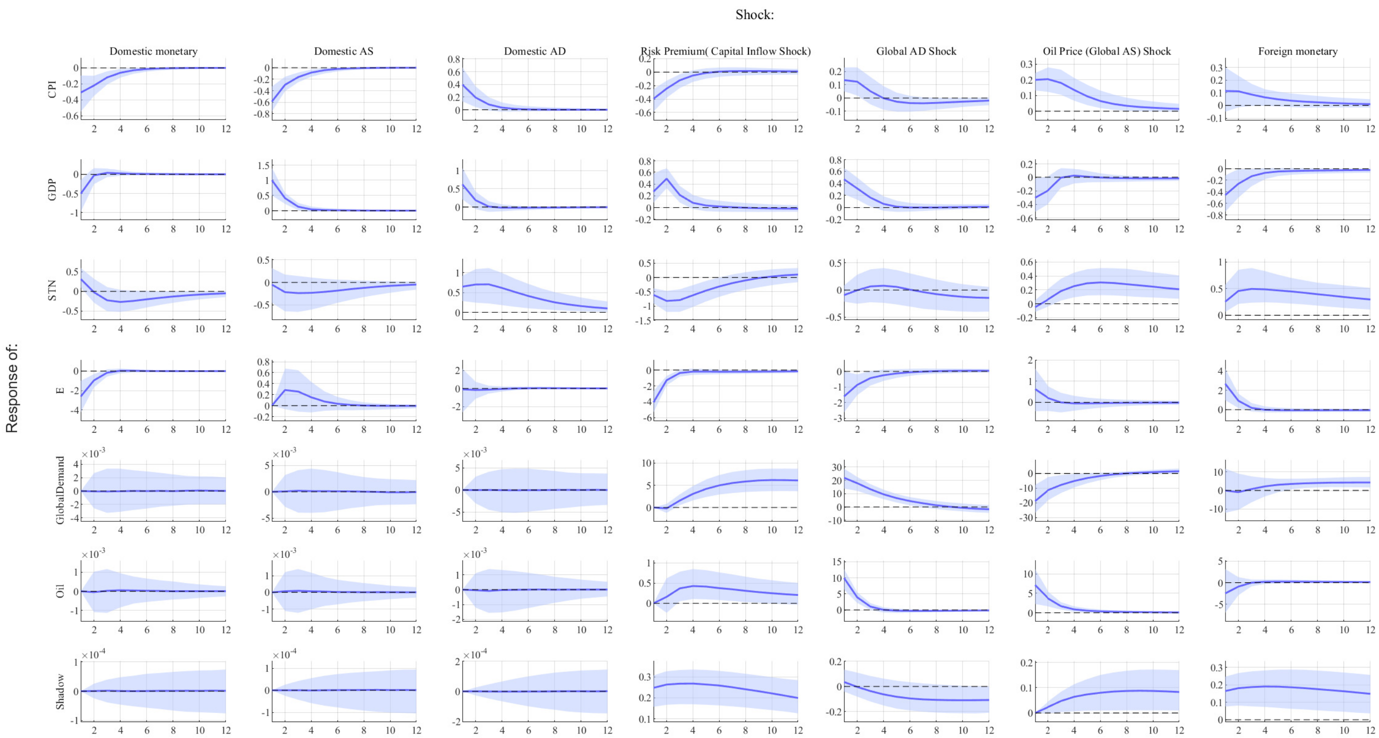
Figure 5.5: **REER, SVAR**



5.3 Kilian (2009) Global Real Activity Index

Lutz Kilian, in one of his seminal papers (Kilian, 2009) proposed a global real activity indicator for a measure of the component of the worldwide real economic activity that drives demand for industrial commodities in global markets. His index is based on dry cargo single voyage ocean freight rates and it is explicitly designed to capture shifts in the demand for industrial commodities in the global markets. This is a monthly, percentage deviation from trend index and I converted it into a quarterly series by simply taking the averages. Instead of only relying on the world industrial production index (excluding the construction activities) published by the CPB, I also use the Kilian's real activity index. The impulse response results are as follows:

Figure 5.6: **Kilian Global Demand Index, SVAR**



Section 6

Conclusion

In a financially and economically integrated world, the importance of global shocks on the emerging markets has reached at a stage that the policy makers in economies have no option but to consider and analyse the sources and the consequences of the external shocks to a great extent. In the realm of policy rates of emerging and advanced economies move together by former following the latter, it is noteworthy to examine how the changes in global interest rates affect the macroeconomic dynamics in emerging economies. Recent literature on the transmission of the foreign monetary conditions on emerging market economies has clarified the significance of external disturbances on these economies by adopting several methods, ranging from structural DSGE models to either bilateral or panel VAR models. However, identification of foreign monetary policy shocks together with global aggregate supply and demand shocks has remained a relatively less explored research area for Turkey. As an emerging economy, Turkey is a good natural laboratory to examine the global shocks as the domestic macroeconomic dynamics can not be considered in isolation from the external world. Starting from the question of "How does a U.S. monetary tightening affects Turkish economy", in this paper, I attempted to identify domestic and foreign shocks with regards to their monetary, aggregate supply and aggregate demand counterparts in order to quantify the impact of external shocks on Turkish economy.

I apply a Structural Vector Auto-regressive model to the real and financial block of Turkish economy in order to identify both global and domestic disturbances for the main macro aggregates of the Turkish economy. While the estimations are computed by Bayesian procedures, the sign and zero restrictions follow the algorithm of the Arias et al. (2014), the block exogeneous nature of the external shocks is from the seminal contributions to the macroeconometrics literature by the Cushman and Zha (1997).

Following US monetary tightening, the results demonstrate a significant depreciation of the Turkish lira, a fall in the real output level and the rise in overall price level in the economy. On the global side, while the oil prices fall, the global demand does not manifest a significant response. Moreover, there has been a positive policy reaction by the Central Bank of the Republic of Turkey after a US monetary tightening as an anticipated policy move as a small economy. This reaction is a proof of an existence of an global interest rate contagion valid in the international macroeconomics literature. Most of the research attempted to explore this contagion effect found evidence in favor of the emerging markets being a follower of the core, advanced economies. In this context, (Rey, 2015) argues that Mundellian trilemma could even boil down to a dilemma as independent monetary policies are only possible as long as capital flows are controlled via the macro-prudential tools and measures. Apart from the analyses of the impulse response functions, the forecast error variance decomposition (FEVD) reveals significant information about each variable's relative importance on forecasting a specific variable in concern.According to the FEVD's, global shocks outweigh the importance of domestic ones for predicting the financial variables in Turkish economy. In terms of the price level and the domestic output, global and domestic shocks constitute approximately the same amount of information while explaining the variation in these variables. On the contrary, global shocks (i.e, FED monetary tightening, global supply and demand shocks) have more role than that of domestic ones in explaining the forecast error of the financial variables. The paper contributes to the literature by investigating not only the US monetary policy shocks on Turkey, but also the impact of global supply shock and demand shocks identified by using a global demand indicator and the oil prices.

With regards to the connection of oil market and monetary policies, although the findings of the Kilian and Vega (2011) reported no feedback effect from US macroeconomic news at daily and monthly frequency, the quarterly Structural VAR models suggested an inverse relationship between a FED funds rate oil prices, as supported by Anzuini et al. (2012).

The results have two practical policy implications in terms of economic modelling for the Turkish economy. For an empirically successful policy design, both global and domestic factors need to be taken accounted for. In this respect, the Federal Reserve's interest rate policy path matters for the monetary policy design for the Central Bank of Turkey. Also, as evident from the impulse-response functions, Central Bank of Turkey does not respond immediately to the oil price shocks. As argued in the oil market literature, in fact the source of the shock matters for policy makers while shaping the future monetary policy decisions. It sheds important information about the CBRT that the origin of the oil price shock has to be considered. Whether it is a demand side oil price shock that distorts the pricing behavior and puts upward pressure on the price dynamics or a supply side shock due to constraints of oil production is a central determinant for the central banks to take appropriate policy actions. Moreover, as the global shocks pose as much pressure as the domestic shocks to the economy, the impact of external disturbances have to be monitored closely.

The paper is open to some extensions. First of all, to compare the impact of ECB and FED, a wider identification scheme can be utilized that encompasses the ECB policies too while using European monetary policy's shadow rates. Second, as the literature expands into a global setting, a Global VAR (GVAR) model can be applied while incorporating both ECB and FED into the system with other countries in the model. And thirdly, time-varying parameter SVAR model can be build in order to account for possible non-linearities in the system.

Appendix A

Algorithm For Sign Restrictions

1. Define the restriction matrices, S_j, M_j, $M_{l,j}$ and $M_{u,j}$ for $j = 1, 2, \ldots, n$.

2. Define the number of successful iterations regarding the algorithm.

3. At iteration n, draw the reduced-form VAR coefficients $B_{(n)}$ and $\Gamma_{(n)}$ from their posterior distributions, and recover the model 3.1.

4. At iteration n, obtain $\Psi_0^{(n)}$, $\Psi_1^{(n)}$, $\Psi_2^{(n)}$, ... from $B_{(n)}$.

5. At iteration n, calculate the preliminary structural matrix and generate $\overline{\Psi}_0^{(n)}$, $\overline{\Psi}_1^{(n)}$, $\overline{\Psi}_2^{(n)}$, ... from 3.17. Create the preliminary stacked matrix of 3.23.

6. At iteration n, draw a random matrix X from a standard normal distribution. By using the QR decomposition, obtain an orthonormal matrix Q as the structural matrix.

7. At iteration n, compute a candidate structural impulse response function matrix of Eqn. 3.20

8. Check if the restrictions hold. If yes, keep the matrix Q and go for the next iteration. If not, discard and repeat the steps 3 to 8, until successful number of restrictions are obtaines after discarding the burnt-in iterations

Appendix B

Data Properties

Table B.1: Data Sources and Definitons

Variable	**Source**	**Definititon**	**Transformation**
		Global Variables	
Federal Funds Rate	St. Louis FED Economic Database	Quarterly averages	Levels
Shadow rates	Wu-Xia (2013), Krippner(2013)	Quarterly averages	Levels
Oil prices	Bloomberg	Brent crude oil price in US dollars	QoQ-Log difference
World industrial production	CPB Netherlands Bureau for Economic Policy Analysis	World industrial production, excluding construction	Seasonally adjusted, QoQ-Log difference
Global real activity index	Kilian (2009)	Real activity index based on dry-cargo bulk freight rates	Levels
		Domestic Variables	
Output	TURKSTAT, CBRT	Real production level	Seasonally adjusted, QoQ-Log difference
Price level	TURKSTAT	Consumer price index level	Seasonally adjusted, QoQ-Log difference
Policy rate	CBRT, BIST	Main policy interest rate	levels
USD/TRY Exchange rate	Bloomberg	Nominal exchange rate against USD dollar	Monthly averages
REER	BIS Statistics	Real effective exchange rate of Turkey	QoQ-Log differences

Table B.2: Unit Root Tests

	ADF Test $H_0 =$ **Unit root**		**KPSS Test** $H_0 =$ **Stationary**	
	Level	1st Difference	Level	1st Difference
Shadow Rates	-2.050	-2.327	.400	.172
CBRT Policy Rate	-1.767	-4.852	.585	.683
TR/USD Exchange Rate	-6.843	-8.919	.779	.194
World Industrial Production	-1.438	-3.495	.983	.044
Oil Price	-2.660	-6.301	.254	.156
Domestic Production	-0.205	-5.619	1.006	.085
Consumer Price Level	3.670	2.179	1.013	.802
Critical Values				
%1	-3.553		.216	
%5	-2.915		.146	
%10	-2.592		.119	

Appendix C

Variance Decomposition and Historical Decomposition Analysis

Table C.1: **Price Level, Variance Decomposition**

Horizon	Domestic monetary	Domestic Supply	Domestic Demand	Risk Premium	Global Demand	Global Supply (Oil Price)	Foreign monetary
2	0.08	0.35	0.13	0.15	0.03	0.06	0.02
4	0.08	0.33	0.12	0.15	0.04	0.07	0.02
6	0.08	0.32	0.12	0.15	0.05	0.07	0.03
8	0.08	0.32	0.12	0.15	0.05	0.07	0.03
12	0.08	0.31	0.12	0.15	0.05	0.07	0.03

Table C.2: **Domestic Output Level, Variance Decomposition**

Horizon	Domestic monetary	Domestic Supply	Domestic Demand	Risk Premium	Global Demand	Global Supply (Oil Price)	Foreign monetary
2	0.08	0.25	0.09	0.05	0.07	0.12	0.10
4	0.08	0.24	0.09	0.05	0.08	0.12	0.10
6	0.08	0.24	0.09	0.05	0.08	0.12	0.10
8	0.08	0.24	0.09	0.06	0.08	0.12	0.10
12	0.08	0.24	0.09	0.06	0.08	0.12	0.10

Table C.3: **CBRT Policy Rate, Variance Decomposition**

Horizon	Domestic monetary	Domestic Supply	Domestic Demand	Risk Premium	Global Demand	Global Supply (Oil Price)	Foreign monetary
2	0.06	0.05	0.27	0.34	0.01	0.004	0.07
4	0.05	0.05	0.25	0.31	0.03	0.006	0.12
6	0.05	0.05	0.24	0.28	0.04	0.008	0.13
8	0.05	0.05	0.23	0.26	0.05	0.01	0.15
12	0.05	0.05	0.22	0.24	0.06	0.01	0.17

Figure C.1: **Historical Decomposition of the Model Variables**

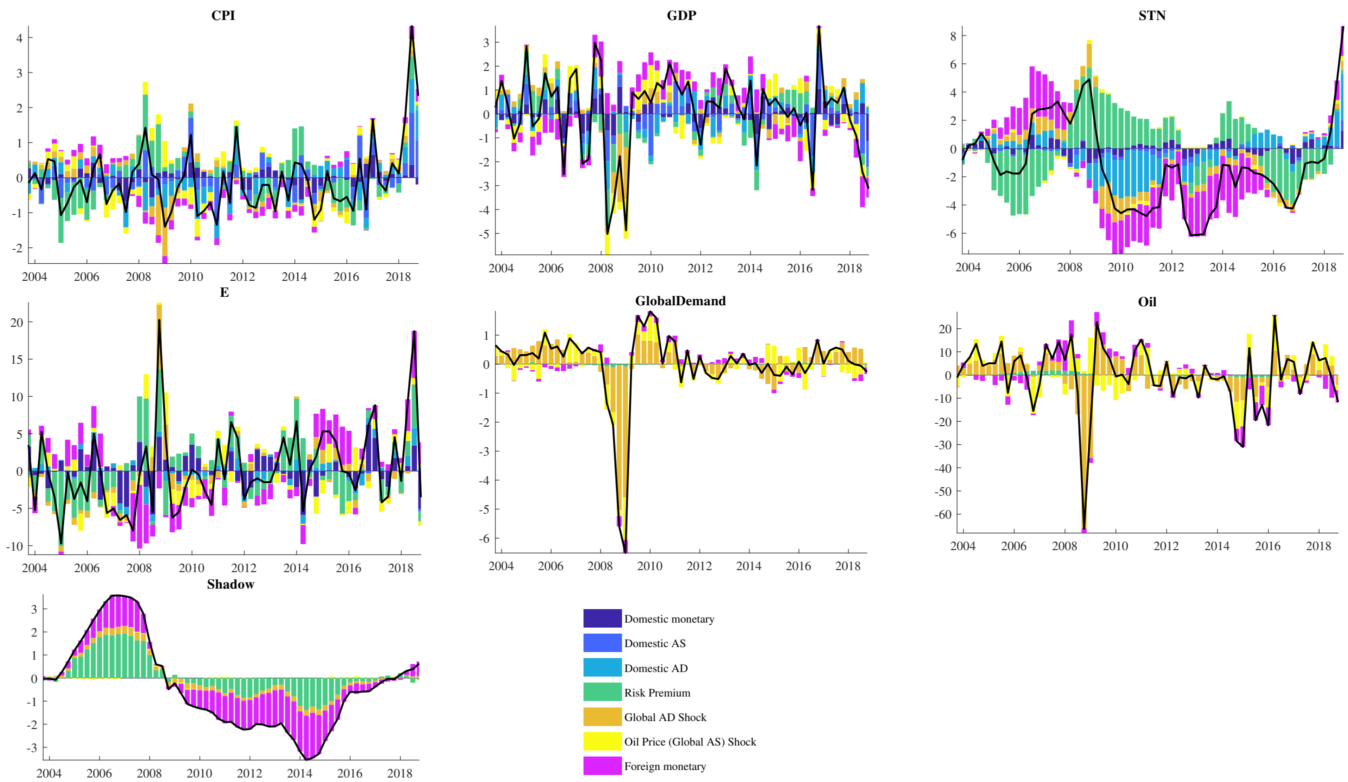
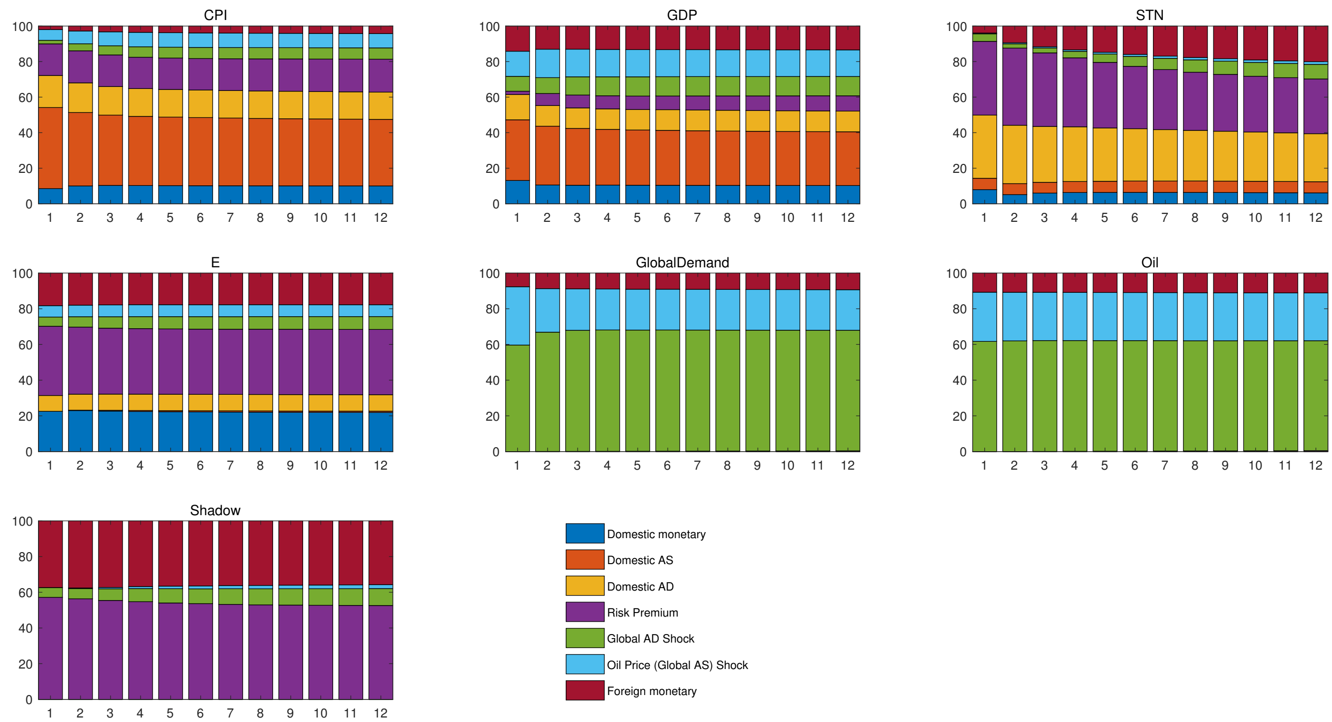


Figure C.2: **Forecast Error Variance Deocomposition of the Model Variables**



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