Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

How Much of the Macroeconomic Variation In Ukraine Originates From External Shocks?

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Declaration of Authorship

I hereby declare that I compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, January 4, 2018

Signature

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Abstract

In this thesis, we investigate the relative importance of foreign shocks in the Ukrainian economy by estimating a small-scale SVAR model with block exogeneity restriction over the period 2003:2 – 2016:12. We find that external shocks from the EU and Russia account for a significant share of the macroeconomic variation in Ukraine. In particular, external shocks account for up to 97 % of variance in Ukraine's output and 85 % in inflation. Remarkably, foreign monetary policy shocks (both from the EU and Russia) account only for a tiny share of variance in all Ukrainian macro variables. Finally, we show that the inclusion of Russia in the 'foreign' block is important to achieve correct model specification. Without accounting for the effects of the Russian economy, Ukrainian variables over-react to shocks originating from the EU. We conclude that the National Bank of Ukraine should closely track external developments to achieve inflation targets.

JEL Classification	E52, F41, F42
Keywords	vector autoregression, foreign shocks, monetary policy, Ukraine

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Abstrakt

Cílem diplomové práce je prozkoumání relativní důležitosti zahraničních šoků na ukrajinskou ekonomiku v časovém období 2/2012 – 12/2016. Cíle je dosaženo pomocí aplikace SVAR modelu s blokovou restrikcí. Práce indikuje, že se externí šoky způsobené EU a Ruskem podílejí významnou mírou na makroekonomických změnách ukrajinské ekonomiky. Konkrétně pak zahraniční šoky tvoří až 97% změn v produkci ukrajinské ekonomiky a až 85% inflace. Na druhou stranu však zahraniční měnové šoky (obojí z EU a z Ruska) tvoří jen minimální podíl na změnách makroekonomických proměnných ukrajinské ekonomiky. Na závěr ukazujeme, že zahrnutí Ruska do "zahraničního" modelu je důležité k dosažení správné specifikace modelu. Pokud bychom nebrali v úvahu efekty ruské ekonomiky na ukrajinskou, zjišťujeme, že proměnné ukrajinské ekonomiky přehnaně reagují na šoky pocházející z EU. V práci docházíme k závěru, že by Ukrajinská národní banka měla důkladně sledovat externí vývoj k naplňování jejích inflačních cílů.

Klasifikace	E52, F41, F42
Klíčová slova	vektorová autoregrese, zahraniční šoky, měnová politika, Ukrajina

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Acronyms

ADF	Augmented Dickey-Fuller test
BVAR	Bayesian Vector Autoregressive Model
CIS	the Commonwealth of Independent States
ECB	the European Central Bank
EMBI	Emerging Market Bond Index
EMEI	Emerging Market Equity Index
EMU	European Monetary Union
FAVAR	Factor-Augmented Vector Autoregressive Model
FEVD	Forecast Error Variance Decomposition
GVAR	Global Vector Autoregressive Model
IMF	International Monetary Fond
IRF	Impulse Response Function
IT	Inflation Targeting
KPSS	Kwiatkowski–Phillips–Schmidt–Shin test
NBU	the National Bank of Ukraine
OECD	The Organisation for Economic Co-operation and Development
PP	Phillips-Perron test
SVAR	Structural Vector Autoregressive Model
VAR	Vector Autoregressive Model
VECM	Vector Error Correction Model
ZLB	Zero Lower Bound

Master's Thesis Proposal

Author:	Bc. Alona Fedorova
Supervisor:	PhDr. Jaromír Baxa, Ph.D.
Defense Planned:	January 2018

Proposed Topic:

How much of the Macroeconomic Variation in Ukraine originates from External Shocks?

Motivation:

It has been almost a decade since the monetary authority in Ukraine started considering adoption of Inflation Targeting (IT), following experience of other Eastern European countries, which had similar problems with monetary policy effectiveness, in particular, high inflation rates and their high volatility. Understanding that low and stable inflation is one of key conditions for sustainable economic growth achievable by a central bank, IT was considered by the National Bank of Ukraine (NBU) as the most appropriate monetary regime for creating the environment of low and stable inflation. A formal regime of IT was declared at the end of 2016, in the principles of the monetary policy for 2017-2020.

The accuracy of achieving inflation targets is determined by exogenous factors. Therefore, for an intermediate size open economy, such as Ukraine, the research on external sources of inflation and output movements is of great practical significance. This type of analysis is usually done using Vector Autoregression Models (VAR). As examples of such research for Central and Eastern European countries can be mentioned papers of Mackowiak (2006) and Horvath and Rusnak (2008).

There is not much research done in this area for Ukraine, which may be caused by limitations in data availability in previous years. Ukrainian researchers mostly focus on Monetary Policy transmission and effectiveness of certain channels (Petryk 2008, Bilan and Kryshko 2008) or determinants of inflation (Leheyda 2005, Hryvniv et al. 2005), rather than sources of inflation and output movements. But there exist several global studies that include analysis for Ukraine (Galesi and Lombardi, 2009).

Hypotheses:

1. Hypothesis #1: External shocks are an important source of aggregate fluctuations in Ukraine.
2. Hypothesis #2: Ukrainian economic environment is significantly influenced by Russian monetary policy.
3. Hypothesis #3: Euro area interest rate shocks account for a sizable fraction of the spillovers to Ukraine from the rest of the world.

Methodology:

For the analysis, I am going to use information from the World Bank Database, OECD Data, State Statistics Service of Ukraine and National Bank of Ukraine. The decision about the frequency of data will depend on its availability. Mostly, for this type of analysis quarterly data is used, but there are 25 years of statistical data available for Ukraine with just 10 years of relative stability, which in quarterly frequency may be not enough for the analysis. Given the limited length of the available macroeconomic dataset for Ukraine due to frequent crises since its independence and war in Donbass since 2014, Bayesian methods could be employed as way of dealing with the problem of over-parameterization.

One option of methodology, which could be used for estimation of the influence of the foreign shocks, is structural vector autoregression model (SVAR) with blocks. In this case, first, I will consider VAR model for the home economy. Then I will add two exogenous blocks, which will be presented by vectors of variables of the EU (represented by Germany, as it is the biggest European trade partner of Ukraine) and Russian economies, because of high dependency of Ukrainian economy on mutual trade with these countries. Since Ukrainian economy is much smaller than economies of Germany and Russia, it is reasonable to assume that Ukrainian variables do not influence the variables of abovementioned countries. Empirical results will be obtained from interpretation of impulse response functions and forecast variance decomposition.

But other methodologies will be considered as well and the final decision will depend on its appropriateness for analysis of data from Ukraine.

Expected Contribution:

Earlier studies used quite short datasets and did not focus in particular on sources of inflation and output movements in Ukraine. Results of such analysis can guide the National Bank of Ukraine that needs to decide how closely to track external developments so as to achieve inflation targets within the IT regime employed by Ukraine starting from 2017; and theorists who want to know which kind of shocks to include into their models, which could be used later on by Ukrainian central bank for forecasting and monetary policy analysis.

Outline:

1. Introduction: I will explain the motivation for the topic.
2. Literature review: I will briefly describe how this topic was studied before and presented in the academic literature.
3. Data: I will describe which variables and why were chosen for the analysis.
4. Methods: I will briefly explain my VAR model with two exogenous blocks.
5. Empirical Results: I will discuss obtained impulse responses, variance decomposition, and robustness checks.
6. Concluding remarks: I will sum up my findings and their policy implications, including suggestions for future research.

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Author **Supervisor**

1 Introduction

It has been almost a decade since the monetary authority in Ukraine started considering adoption of Inflation Targeting (IT), following the experience of other Eastern European countries, which had similar problems with monetary policy effectiveness, in particular, high inflation rates and their high volatility. Understanding that low and stable inflation is one of the critical conditions for sustainable economic growth achievable by a central bank, IT was considered by the National Bank of Ukraine (NBU) as the most appropriate monetary regime for creating the environment of low and stable inflation. The NBU formally declared a regime of IT at the end of 2016, in the principles of the monetary policy for 2017-2020.

The accuracy of achieving inflation targets largely depends on exogenous factors. Therefore, for an intermediate size open economy, such as Ukraine, analysis of external sources of inflation and output movements is of great practical significance. Results of such analysis can guide the National Bank of Ukraine that needs to decide how closely to track external developments to achieve inflation targets within the IT regime employed by Ukraine starting from 2017; and theorists who want to know which kind of shocks to include into their models for forecasting and monetary policy analysis. In this work, we do not provide with details on institutional development and policy of Ukraine or the history of transition, as this is not an objective of this work and has been done in a range of papers; see, for example, Aslund (2008), Sutela (2012).

There is not much research done in this area for Ukraine, which is mostly caused by limitations in data availability in previous years. Nevertheless, several global studies include analysis for Ukraine (Galesi & Lombardi 2009, Feldkircher 2013). Ukrainian researchers mainly focus on monetary policy transmission and effectiveness of specific channels (see Petryk 2008, Bilan & Kryshko 2008) or determinants of inflation (see Leheyda 2005, Goridko & Nizhegorodtsev 2013) and economic growth (Bazhenova 2012), rather than external sources of variation in inflation and output. In addition, existing papers that employ VAR models to investigate fluctuations in the Ukrainian economy usually include only commodity prices (metals, oil) to account for external shocks, so the impact of other shocks originating abroad remains unexplored.

The objective of this thesis is to investigate the relative importance of foreign shocks for macroeconomic variation in Ukraine, mainly shocks from the EU (eurozone) and Russia, main trade partners of Ukraine. First, we want to estimate how important are external shocks for aggregate fluctuations in Ukraine in general; second, to investigate whether Ukrainian economic environment is significantly influenced by Russian monetary policy; third, to assess whether euro area interest rate shocks account for a sizable fraction of macroeconomic variation in Ukraine.

This type of analysis is commonly done using Structural Vector Autoregressive (SVAR) models and provides with reasonably good results if correctly specified (see Maćkowiak 2006a, Allegret et al. 2012, Babecká Kucharčuková et al. 2016, etc.). The SVAR approach employs economic theory to sort out contemporaneous links among the variables to achieve identification of parameters. Moreover, we impose so-called "block exogeneity" restriction introduced by Cushman & Zha (1997). In the case of small open economies it is especially beneficial as it allows for including more international variables to account for the diversity of foreign shocks, while reducing the number of parameters that need to be estimated (see Leeper et al. 1996, Buckle et al. 2007), and identification of policy reaction functions (see papers of Cushman & Zha 1997, Brischetto & Voss 1999, Kim & Roubini 2000). Accordingly, we estimate an SVAR model, which includes 11 variables divided between two blocks – Ukrainian 'domestic' block and a 'foreign' block for the economies of the EU and Russia, and it is assumed that variables of the EU and Russia affect the Ukrainian variables, but not vice versa. We use monthly data over the period February 2003 - December 2016 (167 observations). For the EU's variables, we use aggregated data over 19 countries that are part of the eurozone.

We find that external shocks account for a significant share of the macroeconomic variation in Ukraine. In particular, external shocks account for up to 97 % of volatility in Ukraine's output and 85 % in inflation. Among external shocks, output shock originating in the EU is the most influential. It accounts for 84-90 % in the variance of real output in Ukraine, 60-75% in the variance of inflation (in the middle and long run) and 40-68 % in the variance of the nominal UAH/EUR exchange rate. However, for the nominal interest rate in Ukraine the most influential is inflationary shock from the EU, which accounts for 44-77 % with its strongest impact in the short run. Remarkably, foreign monetary policy shocks (both from the EU and Russia) account for about 1 % of the variance in real output and the price level in Ukraine; the effect is significant according to impulse responses. Our findings are in line with the results of other studies. Finally, we find that the inclusion of Russia in the model is important to achieve correct model specification and avoid an overstatement of the impact of shocks originating from the EU on the Ukrainian economy.

The remainder of the thesis is organised as follows. In section 2, we review the literature on the international transmission of shocks focusing on autoregressive models, as well as empirical studies on transmission in Ukraine. General aspects of methodology, description of the model and data can be found in Section 3. Section 4 presents empirical results. The main concluding remarks are summarized in Section 5. Appendix with data description and more detailed results follows.

2 Literature review

2.1 International Transmission of Shocks

In this section, we provide with a brief overview of literature devoted to the international transmission of shocks. We specifically focus on papers that apply autoregressive models to investigate how external shocks are transmitted to the domestic economy and how these external shocks affect domestic economy.

The literature on the international transmission of different shocks extends works on monetary policy transmission in "closed" economies, based on different identification mechanisms of vector autoregressive models (VAR). Such open-economy VARs, which track the dynamics of variables of both domestic and foreign economies, allow evaluating the international transmission of shocks and macroeconomic spillovers among countries. In this case, identification mostly relies on the assumption that a small economy is subject to shocks from a larger one (typically the US in America or Germany in EU). This small open economy assumption results in exogeneity restrictions in the model. Cushman & Zha (1997) study monetary policy in Canada, using world commodity prices and key macroeconomic variables in the US to measure external shocks. They apply VAR with block exogeneity restriction because if they run VAR with 11 variables ordered in the way, so that exogenous ones are put at the end, or use Cholesky decomposition, in both cases, this leads to puzzling results. They argue that previous literature was unable to identify the monetary policy shock accurately, as it did not control for external factors explicitly. Similarly to the previous paper, Dungey & Pagan (2000) create a model with two blocks of structural equations, so as the first block represents the domestic economy and the second block represents the international economy. Equations in the international block do not include dependent variables from the block of the domestic economy, which follows from the small open economy assumption. Analogously, Kim & Roubini (2000) apply an open economy VAR to solve the price puzzle in a closed economy. Dungey & Fry (2003) use a structure with three blocks to eliminate the effects of shocks originating from Japan and the US on the Australian economy. Dees et al. (2007) and Pesaran et al. (2004) also apply exogenous variables and sectors in their models, to identify the relative importance of a range of international linkages and regional dependencies.

More works are devoted to the effects of foreign shocks on the domestic economy. Many researchers focus in their papers on spillovers from systematically important countries, such as the US, EU, Japan, to other countries or regions (see Kim 2001, Giordani 2004, Canova 2005, Maćkowiak 2006b, 2007, Allegret et al. 2012, Erten 2012, Feldkircher 2013, Babecká Kucharčuková et al. 2016). The main finding of these studies is that a large part of the variation in domestic variables comes from external shocks. For example, Kim (2001) in his paper focuses on the international transmission of US monetary policy shocks for the flexible exchange rate period across non-US G-7 countries using VAR modelling. He finds that US expansionary monetary policy shocks lead to booms in G-6 countries. In this transmission, it is the decrease in world real interest rates that matter most, while changes in trade balance seem to play a minor role. In contrast to previous studies, Kim (2001) controls for inflationary and supply shocks to show that the reaction of G-6 monetary authorities to US monetary policy appears being not that strong, except Canada. Giordani (2004) studies responses of a small open economy to foreign shocks. He estimates a structural model on US-Canadian data from a class of New-Keynesian models and compares it with Bayesian VAR. Giordani (2004) finds that US shocks are a significant source of variation in all Canadian variables. Therefore, he concludes that international variables should figure prominently in both optimal and actual monetary policy rules.

Applications to Latin American and Asian economies can be found in Canova (2005), Maćkowiak (2006b, 2007), Allegret et al. (2012). Economies of the countries of both regions are to some extent similar in their vulnerability to regional contagion effects because of their high openness and interdependence. The studies find that external shocks cause a significant proportion of macroeconomic variation in these economies. Interestingly, results of Canova (2005) indicate no significant difference between transmission of the US shocks in the Latin American countries with fixed exchange regime and countries with more flexible arrangements. Maćkowiak (2007), using SVAR, shows that US monetary policy shocks are less critical for emerging markets from East Asia and Latin America in contrast with other external shocks, as they account for less than 10% of macroeconomic variation on average. On the other hand, he mentions that responses of the price level and real output to the US monetary policy shock are more significant than in the US itself. Similarly, Maćkowiak (2006b), using BVAR, finds that Japanese monetary shocks account only for a small fraction of fluctuations in real output, trade balances and exchange rates in East Asia. In particular, he finds no evidence that expansionary monetary policy shocks from Japan contributed to the Asian crisis. More recently, Allegret et al. (2012) have studied the relative importance of external shocks in domestic fluctuations of East Asian countries and to which kind of reaction between the considered economies they lead, asymmetric or symmetric. Their results show that the impact of considered external shocks on domestic variables has increased since the mid-1990s with the stronger impact of real external shocks compared to the effect of monetary and financial shocks.

Given the extent of trade and financial linkages within the EU, it is reasonable to expect that the economic developments and common monetary policy of the euro area can have a significant impact on other countries even if they keep an autonomous monetary policy. This assumption is confirmed by studies of Maćkowiak (2006a), Horváth & Rusnák (2009), Feldkircher (2013), Babecká Kucharčuková et al. (2016). Maćkowiak (2006a) examines to what extent the macroeconomic variation in the Czech Republic, Hungary, and Poland is caused by external shocks. He uses Germany as a proxy for external shocks from EU and sets up an autoregressive model with block restrictions, which includes key macro variables from both Germany and one of the small open economies. As a result, he finds evidence that external shocks can explain a significant proportion of the variation in domestic variables in Central European countries. Horváth & Rusnák (2009) use more variables and build SVAR model in the New Keynesian spirit. Their findings for Slovakia (before it joined the EMU) indicate that the impact of ECB policy on the economy is even stronger than the impact of the domestic policy. Finally, Feldkircher (2013) applies a global VAR model for 43 countries (including Ukraine and Russia), which is a compact representation of the world economy. He finds that Central Europe reacts equally strongly to the US and euro area output shocks. On the other hand, ECB policy has a long-run effect on output in the region, although the impact is moderate. Babecká Kucharčuková et al. (2016) get similar results for six non-EMU countries and further extended the analysis to study the impact of conventional and unconventional monetary policy of ECB at the ZLB. Using block-restricted SVAR model for each country they find that conventional monetary policy shocks have a generalised effect on output, exchange rates, and inflation. On the contrary, unconventional measures cause a variety of responses: exchange rates respond relatively quickly, an impact on output is detected only in some countries, and inflation remains mostly unaffected.

A range of papers focuses on a particular type of shock and how it is transmitted to the real economy. For these purposes, larger and more complicated models are mostly used, so as to allow for more comprehensive analysis of the causes and linkages; among these are Factor-Augmented VAR, Global VAR, VAR with Bayesian techniques, etc. A major result noted in these papers is that the systematically important external shocks explain a large part of the variation in domestic variables of the studied countries. Galesi & Lombardi (2009) create a Global VAR model for 33 countries, including Ukraine, to study international inflationary spillovers caused by oil and food price shocks. They find that a considerable part of the observed price level changes in the vast majority of the regions originates from foreign sources. Furthermore, obtained generalized impulse response functions reveal that the direct inflationary effects of oil price shocks affect mostly developed countries while emerging economies respond more to food price increases. Dees et al. (2007) focus in their paper on the effects of US monetary policy and equity prices shocks, and shocks to oil prices in the euro area. Similarly to the previous study, they also use a Global VAR model, but model the euro area as one region, so the final model includes 26 economies in total. The results show that financial shocks spread rapidly, and often get amplified as they transmit from the US to the euro area. An oil price shock proves to have a statistically significant impact on inflation but has limited impact on output. In contrast, the effects of the US monetary policy shock for the euro area output and inflation are limited and not highly significant. Artis et al. (2007) try to assess the relative importance of financial, trade and policy mechanisms by which shocks are transmitted across countries and employ a trivariate VAR that includes variables for the US, Germany and one other European economy. Mumtaz & Surico (2009) examine the impact of international supply and monetary shocks, as well as the domestic monetary shock on the economy in the UK using a large panel of data for 17 industrialized countries and a Factor-Augmented VAR. A number of external demand shocks and their impact on emerging economies are analysed in a paper of Erten (2012). Using a Bayesian VAR model with informative priors on the steady state, global financial conditions, and external demand variables, he finds that almost half of the variation in GDP growth of the studied countries comes from external factors. The results slightly differ among the regions: emerging Latin American countries are more sensitive to external shocks than emerging Asia and China.

2.2 Empirical Studies on Transmission in Ukraine

There is not much research done in this area for Ukraine, which is mainly caused by limitations in data availability in previous years. Ukrainian researchers generally focus on monetary policy transmission and effectiveness of specific channels (see Petryk 2008, Bilan & Kryshko 2008) or determinants of inflation (see Leheyda 2005, Hryvniv et al. 2005, Goridko 2011, Kirchner et al. 2008, Goridko & Nizhegorodtsev 2013), rather than sources of variation in inflation and output movements. Nevertheless, several global studies include analysis for Ukraine (see Galesi &

Lombardi 2009, Feldkircher 2013), as well as studies that investigate external shocks of the economy of Ukraine (see IMF 2005, IMF 2008, Kopych & Bardyn 2015).

Galesi & Lombardi (2009) do not provide with specific results for Ukraine, but rather with general conclusions for the Emerging European countries. They find that the direct inflationary effects of oil price shocks mostly affect developed countries and for emerging economies have less sizeable effects, while the direct inflationary effects of food price increases especially affect emerging economies.

According to results obtained by Feldkircher (2013), Ukraine can be considered as one of the economies most vulnerable to all sorts of foreign shocks. More specifically, the economy reacts strongly to the U.S. output shock (1%) and even more strongly to the corresponding euro area output shock (1.2%), as well as euro area monetary shock (-0.7%). His findings furthermore support the importance of Russian knock-on effects for the Commonwealth of Independent States (CIS) and in particular for the Ukrainian economy. As a result, second-round effects from the oil price-driven Russian expansion seem to offset the decrease in Ukraine's output caused by the increase in oil prices, resulting in a slight increase in output by 0.4%. More details about oil price shock and its second-round effects can be found in a paper of IMF stuff (IMF, 2004).

Kopych (2015) among factors for the extreme vulnerability of the Ukrainian economy mentions slow adjustment of the real estate bubble that emerged in 2003–2008, excessive credit growth in 2006–2008, accumulation of private and public debt, and insufficient investments. IMF (2017) mentions an economic structure of Ukraine, which compared to other IT countries, is more sensitive to exchange rate volatility. In particular, the Ukrainian economy is characterized by a higher exchange rate pass-through, higher sensitivity to commodity prices, and a high degree of dollarization. In addition, Ukraine has less developed financial markets with a low level of stability, which in turn also makes Ukraine more vulnerable to external shocks and may threat consistent policies in the future by imposing two conflicting objectives: the financial stability objective and the price stability objective. IMF (2005) highlights the dependence of Ukrainian economic growth on exports and accordingly on world prices of raw materials, in particular metals (steel), as it is the main category in Ukraine's goods export.

Leheyda (2005) studied determinants of inflation in Ukraine accounting for both internal and external factors, employing Johanssen co-integration method and Vector Error Correction (VECM) model. The results show a presence of relationships between level of inflation and the long-run money demand, purchasing power parity and markup pricing so that they may affect prices in the long run. In the short-run, prices are somewhat more affected by inertia in inflation, money supply, wages, exchange rate and real output as well as some exogenous shocks. Similar results were obtained by Kirchner et al. (2008). They find a substantial influence of external factors on inflation, in particular, commodity prices and dynamics in the exchange rate. Also, they discover persistent effects of the dynamics of unemployment on the level of inflation.

IMF staff team (IMF, 2005) provides with the analysis of external risks of Ukraine and conducts an empirical analysis of the link between the price of steel, a dominant category in Ukraine's goods export, and Ukraine's balance of payments and economic growth. Due to relatively large share of steel in total goods exports, real economic growth in Ukraine has been tightly linked to steel prices during 2000's. According to the results of the analysis obtained using VAR methodology, the pure price impact of the shock is expected to be large: a decrease of the current account by over 5 percent of GDP relative to its baseline path in 2006. Furthermore, the author highlights the fact that the impact of the shock is not limited by the direct price effect and may affect the economy of Ukraine more broadly through both trade volumes and real domestic demand.

These findings were confirmed three years later in another staff work (IMF, 2008). In contrast to the previous study, the authors investigate the effect of a decrease in the steel price not only on Ukraine's trade balance but also its contribution to macroeconomic volatility in general. They employ a simple VAR model with four endogenous variables. The results of the analysis show that a decline in steel prices by 10 percent decreases annualized real GDP growth by 1.5 percentage points in the quarter of impact, even though the effect disappears quickly after that, but still results in higher macroeconomic volatility through the indirect effects. The effect on inflation is the strongest only in the third quarter after the shock and results in 2 percentage points lower inflation. Similarly to the previous study, the authors consider shocks to the prices of the main export commodities as one of the biggest threat to Ukraine's economic stability and, accordingly, suggest a range of policy measures to minimize the effect of this type of shocks for the economy.

Kopych & Bardyn (2015) examine domestic and external demand shocks in Ukraine. In particular, they focus on the link between budget deficit, interest and exchange rates and their effect on economic growth in Ukraine. They use vector error correction (VAR/VEC) model and the IS–LM–BP model for interpretation of the relevant relationships within the system. According to their findings, the budget balance accounts for a significant part of the variation in the exchange rate (about 25%) and even more in output (about 53%). The exchange rate and output shock just slightly affect dynamics of the interest rate. The output is mostly affected by the interest rate shock (up to 39%), while the exchange rate shock accounts for no more than 4%.

3 Methodology

3.1 Methodological framework

In this section, we are going to discuss aspects of methodology commonly used for analysis of macroeconomic volatility in an open economy; describe the model implemented in this work; provide with the reasoning for choosing the set of variables and present data.

Works on the analysis of the sources of macroeconomic variation have generally employed vector autoregressive (VAR) models as a tool for identification, measuring, and forecasting the dynamic impact of different shocks from one economy to another. However, the standard VAR models may suffer from highly over-parameterisation, which leads to reduced quality of forecast, unless large samples of data are used. Nowadays, there are different approaches to VAR modelling that have been developed to improve identification power of the models and their forecasting performance. The most common approaches found in the literature are going to be discussed below.

The first option is to conduct the analysis on a bilateral basis, as did Canova (2005) in his study of the transmission of US shocks to eight Latin American countries by separately modelling each pair of countries with the USA on one side and one Latin American country at a time. The unrestricted VAR model for the economy of the US (‘foreign' country) includes a measure of real output, inflation, the nominal interest rate and real balances. The model also includes three variables that account for the state of the world economy or those influences that may cause comovements in the two regions: an index of commodity prices, the emerging market bond index (EMBI) and the emerging market equity index (EMEI). Each ‘domestic’ economy, a Latin American country, includes five basic variables measuring real activity (GDP), inflation (CPI inflation), interest rates (short-term market rates), trade (the ratio of exports to imports) and the international competitiveness (the real effective exchange rate). Such a model also allows for testing of all three types of shocks. The main problem with this approach is that such specification excludes any relations among Latin American countries, which may appear being as significant as the impact from the US.

The second option is Factor-Augmented VAR model (FAVAR). Its main idea is to reduce common variations of several variables across countries into common factors, which are then used to analyse their impact on variables of an individual country. Mumtaz & Surico (2009) create a FAVAR model with macroeconomic variables for 17 the major industrialised economies and main trade partners of the UK to investigate the international transmission. Their model includes factors for international real activity growth, inflation, money growth and interest rates, domestic factors and domestic short-term interest rate. For each 'foreign' country, they use data on real activity (output growth, employment, consumption, and investment), inflation (domestic price indices, wage growth, and import prices), money (monetary aggregates from narrow to broad) and interest rates (short-term) for each country. The data for the 'domestic' country (UK) is similar to data of the 'foreign' block. They include many different real activity indicators, inflation series including components of the retail price index, narrow and broad money and a set of asset prices (house prices and the effective exchange rate). In total, the model includes 600 variables. The authors implement Bayesian techniques, recursive identification, and sign restrictions. Such a model allows for testing of all three types of shocks. The main difficulty of this type of models is that it is not that straightforward how to interpret the common factors that could reflect global shocks, correlated shocks, or spillovers from one country to others.

Another option is Global VAR. The main idea is to reduce the spillovers of individual countries to their proportion in a weighted average for the variable of interest; later on, this weighted average is used to explain the dynamics of individual countries. Such specification allows the spillover effects in such a model to have an explicit interpretation in contrast to those in factor models (see Dees et al. 2007, Galesi & Lombardi 2009, Feldkircher 2013). The main drawback of this approach is that large models with many variables do not always work better in explaining data, but still require explaining a big number of variables.

Bayesian VAR is an approach that helps to deal with the problem of over-parameterisation of standard VAR models because of the limited length of available macroeconomic datasets. The general idea is to use informative priors to shrink the unrestricted model to reduce parameter uncertainty and improve the accuracy of the forecast (see Maćkowiak 2006, Erten 2012, Solmaz & Sanjani 2015).

If one wants to examine the transmission mechanism of foreign shocks in a particular economy, one should specify a multicountry model in a way that would allow accounting for contemporaneous and lagged feedbacks among countries. However, in the case of Ukraine, some issues should be taken into consideration to make the analysis correctly. First, the quality of the data for Ukraine and Russia is debatable so that one might doubt the trustworthiness of the results. Second, periods of hyperinflations, economic and political crises are frequent in the post-soviet countries and make their time series hardly representative of those normal times that one would like to study in terms of the international transmission of shocks. Third, and connected to the previous one, to robustly examine interdependencies among countries, one needs somewhat ‘regular’ cycles; therefore, given short time series, restrictions of degrees of freedom make it difficult to get any reasonable multicountry specification.

Given the reasons mentioned above, we employ an SVAR model with block restriction. This type of models is widely used for this kind of analysis and provides with reasonably good results if it is correctly specified (see Zha 1999, Dungey & Pagan 2000, Dungey & Fry 2003, Maćkowiak 2007, Buckle et al. 2007, Havránek et al. 2010, Allegret et al. 2012, Babecká Kucharčuková et al. 2016).

3.2 Structural VAR

The difference between a VAR and a structural VAR (SVAR) model is well described in a paper of Dungey & Pagan (2000). “VAR is the equivalent of the reduced form, in that each variable is related to lags of all other variables in the system but there are no contemporaneous interactions; SVAR allows for some contemporaneous relations” (Dungey & Pagan, 2000). SVAR modelling employs economic theory to establish contemporaneous links among the variables. To set causal links among variables in an SVAR model, it is required to specify identifying assumptions, that is, to model contemporaneous interdependence between the dependent variables in the regressions. For the reduced form VAR Cholesky decomposition is used, while for an SVAR model the identifying assumptions for imposing restrictions are based on economic theory, to achieve identification of parameters of an SVAR model.

There are several methods to specify the restrictions for identification of the structural parameters in an SVAR model. One way how to determine appropriate restrictions to identify an SVAR model is to use the restrictions that are implied by a fully specified macroeconomic model. However, there is another commonly used method, which is also employed in this work, and its main idea is “to choose the set of variables and identification restrictions that would be consistent with the theory and prior empirical research” (Buckle et al. 2007). The appropriateness of the variables and restrictions can be assessed by the behaviour of the dynamic responses of the model, in particular, whether it is consistent with the preferred theoretical view of the expected response. This method, widely used by many researchers over the last decade, has been described by Leeper, Sims, and Zha in their paper (see Leeper et al. 1996) as “an informal approach to applying more formal prior beliefs to econometric modelling”. The authors consider this method as not much different from other specification methods used in the econometric modelling, but with one condition: the modeller should reveal the methods used for the model selection.

However, Brischetto & Voss (1999) find some issues related to the identification restrictions that have been employed for SVAR modelling. Among these could be mentioned the robustness of the conclusions to alternative reasonable identification restrictions and the difficulty of clearly interpreting which aspects of the model arise from the restrictions and which arise from the data. However, these issues may appear in most multi-equation models and are not inherent only for SVAR modelling.

Typically, structural VARs modelled with any method, require a more general approach for orthogonalisation of reduced form errors than the commonly used Cholesky decomposition, introduced by Sims (1980). Later on, Blanchard & Watson (1986), Bernanke (1986) and Sims (1986) suggested an alternative and a more general approach, but still allowing for restrictions on only contemporaneous structural relationships. This more general approach eased application of so-called “block exogeneity” restriction introduced by Cushman & Zha (1997), Zha (1999) and Dungey & Pagan (2000), which started to be widely used in small open economy SVAR models and for modelling of international linkages.

In this work, we also use block exogeneity restriction due to a range of advantages that it is able to provide (see Buckle et al., 2007). For example, in the case of small open economies, it allows for including in the model more international variables to account for the diversity of foreign shocks, while reducing the number of parameters that need to be estimated. So, Cushman & Zha (1997) included four variables in the ‘foreign’ block of the model of the Canadian economy: US industrial production, US consumer prices, US Federal Funds rate and world total commodity export prices. Dungey & Pagan (2000) included five variables in the 'foreign' block: the US GDP, a real US interest rates, the terms of trade, the ratio of the Dow Jones Index to the US inflation; and they treated Australia's real exports as exogenous. Maćkowiak (2006a) also included five variables in the 'foreign' block: two prices of commodities (an index of export prices of non-fuels, the price of crude oil), and three variables to summarise macroeconomic conditions in Germany (real industrial output, aggregate price level, and interest rate).

Another advantage, stressed by Buckle et al. (2007), is that block exogeneity is helpful for identification of policy reaction functions. For example, it allows for the contemporaneous reaction of monetary policy to various domestic and international variables if their data are likely to be available to the monetary authorities (see papers of Cushman & Zha 1997, Brischetto & Voss 1999, Kim & Roubini 2000). Furthermore, according to Buckle et al. (2007), recent developments in open economy VAR modelling show that the incorporation of a bigger set of international variables in a model appears to be beneficial for correct specification of the model, better identification of contemporaneous interactions, and a bigger number of lagged responses.

3.3 Model

3.3.1 SVAR model with block exogeneity

We model a rather standard SVAR but account for the country-specific conditions to inspect all types of shock from both EU and Russia and focus on the external monetary shocks affecting Ukraine.

Even though Ukraine is a medium size economy, in this work, we treat it as a small open economy. According to textbooks, an economy can be considered as a small open economy if it takes exogenously external variables (Maćkowiak 2006a). We suppose that it is a plausible description of Ukraine, a country that depends on conditions abroad and is relatively small to influence them. In Appendix A, we provide with several stylized facts about Ukraine relevant for the analysis. First, Ukrainian economy is relatively open; the extent of its trade openness is comparable to Denmark and Austria[1], for example. Second, until recently, Russia was Ukraine's main trading partner and accounted for almost a third of Ukraine's exports and imports[2], but this has changed after 2014. Nowadays, Ukraine conducts more than a third of its trade with the EU, while the share of trade with Russia decreased by more than two times[3]. Third, Ukraine's economy is relatively small in terms of income compared to the EU and Russia (Figure 1).

As we consider Ukraine as a small open economy, which is mostly a recipient of the exogenous shocks generated by ECB and Russian policies, any shock affecting

[1] Source: The World Bank, (2016a).
[2] Source: WTO, (2016).
[3] Source: European Commission, (2017).

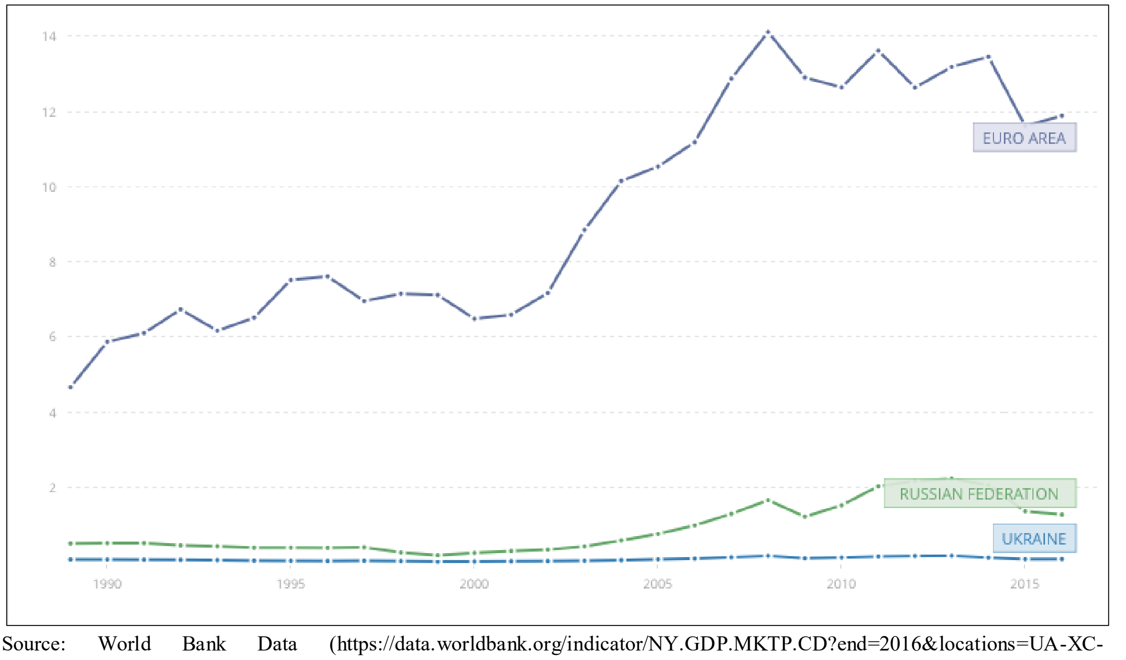
Ukrainian economy will not be transmitted to the euro area or Russia. To account properly for the direction of the causality, we estimate a small-scale structural VAR with block restriction in the spirit of Cushman & Zha (1997), Dungey & Fry (2003) and Maćkowiak (2006a). The identification of the spillover effect of shocks from the large economy on the smaller open economy comes from the restriction of the impact of domestic shocks on the foreign economy.

We start with a general specification. A reduced form VAR model, omitting the deterministic terms, can be written in the following way:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \ ,$$

$t = 1, .., T$, where p indicates the order of the VAR model. As we have M endogenous variables, A_i are ($M \times M$) coefficient matrices, y_t is an ($M \times 1$) vector of observations, and u_t is the ($M \times 1$) vector of structural shocks that generate the data. u_t is serially uncorrelated, and $var(u_t) = \Lambda$, so as Λ is a diagonal matrix, where the diagonal elements represent the variances of the structural disturbances. The model in its general form is similar to the models commonly used in the structural VAR literature (e.g., Cushman & Zha 1997, Zha 1999, Maćkowiak 2006a).

Figure 1: GDP per capita of the EU, Russia, and Ukraine



Source: World Bank Data (https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?end=2016&locations=UA-XC-RU&name_desc=false&start=1989)
Note: The figure shows a line graph of GDP per capita (measured in trillion US dollars) of the EU (19), Russia, and Ukraine over the period 1989-2016.

In order to examine the impact of external shocks on the economy of Ukraine, we employ an SVAR model. To achieve identification, we use economic theory and empirical evidence to impose contemporaneous restrictions, which we describe later in this section. Accordingly, we can write the general structural representation in the following way:

$$\mathrm{A}y_t = A_1^* y_{t-1} + \cdots + A_p^* y_{t-p} + \mathrm{B}\varepsilon_t \ ,$$

where $\varepsilon_t \sim (0, \mathrm{I}_k)$. The matrix A allows for modelling of the contemporaneous relations, $A_i^{*'}s$ $(i = 1, \ldots, p)$ are $(M \times M)$ coefficient matrices, while B is a structural form parameter matrix. The structural shocks, ε_t, are related to the model residuals by linear equations and are orthogonal. Their connection with the reduced form disturbances is obtained by multiplying the above equation by A^{-1}, so that $A_j = A^{-1}A_j^*$ $(j = 1, \ldots, p)$. Thus, we get the following relationship between errors of the reduced and structural forms:

$$u_t = \mathrm{A}^{-1}\mathrm{B}\varepsilon_t \ .$$

Following Amisano & Giannini (1997), we employ the AB-model and combine restrictions for A and B matrices. In this case, the model for innovations becomes $\mathrm{A}u_t = \mathrm{B}\varepsilon_t$.

We can divide the model into a 'domestic' (for Ukraine) and a 'foreign' (for the EU and Russia) block using the notation:

$$y_t = \begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix}, \qquad A_i = \begin{bmatrix} A_{11,i} & A_{12,i} \\ A_{21,i} & A_{22,i} \end{bmatrix}, \qquad \varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix},$$

for all $i = 0, 1, \ldots, p$, with $y_{i,t}$ and $\varepsilon_{i,t}$ each of dimension $(m_i \ x \ 1)$, and A_{ij} of dimension $(m_i \ x \ m_j)$, $i = 1, 2$ and $j = 1, 2$. The model contains m_1 variables in a small open economy ($y_{1,t}$ vector, the 'domestic' block) and m_2 variables that are external to the small economy ($y_{2,t}$ vector, the 'foreign' block), so as $m_1 + m_2 = M$.

As Ukraine's economy is much smaller in terms of income comparing to the EU and Russia, it is reasonable to assume that its shocks are unlikely to have a significant impact on economies of the European countries and Russia. Therefore, we impose the restriction $A_{21}(s) = 0$, for all $s = 0, 1, \ldots, p$, or the so-called "block exogeneity" restriction (see Cushman & Zha, 1997). This restriction implies that variables from the 'domestic' block $y_1(t)$ do not enter the 'foreign' block equations either contemporaneously or for lagged values of the variables. In this case, variables from the 'foreign' block represent a linear combination of external shocks only, while variables from the 'domestic' block are generated both by domestic and external shocks. Otherwise, failing to impose the block exogeneity restriction “may result in misleading conclusions” (Zha, 1999).

3.3.2 Variables

In the next step, we need to decide on the minimum set of variables (types of shock) that we want to include in the model to capture the main relations and suitable for testing all three hypotheses. Hypotheses and corresponding shocks are presented in Table 1. Accordingly, we need a model with such a set of variables that would allow testing supply, demand, and monetary shocks and distinguishing among their effects, so as to be able to interpret the results.

There is apparently considerable scope for the choice of variables. The selection of variables included in the structural VAR model developed in this work is motivated by an interest in understanding the relative importance of foreign shocks from the EU and Russia for the variability of macroeconomic variables in Ukraine, policy interest and a need for a parsimonious specification. Furthermore, as economies are linked through various channels, we want to see to which extent Ukraine’s economy responds to different foreign shocks, as it may differ depending on the nature of the external shock.

Table 1: Types of shock to be included in the SVAR model

Hypotheses	Types of shock
Hypothesis #1: External shocks are an important source of aggregate fluctuations in Ukraine.	*Supply, trade, monetary shocks*
Hypothesis #2: Ukrainian economic environment is significantly influenced by Russian monetary policy.	*Monetary shock*
Hypothesis #3: Euro area interest rate shocks account for a sizable fraction of macroeconomic variation in Ukraine.	*Monetary shock*

Note: The table lists types of shock that need to be included in the SVAR model to test all three hypotheses.

As Maćkowiak (2006a) mentions in his paper on macroeconomic variation in Central European countries, we should be careful about the number of external variables in the ‘foreign’ block of the model. If we omit some external factor, which is important for fluctuations in Ukraine’s economy and dynamics in the ‘foreign’ block of variables, it may result in “incorrect inference regarding the contribution of external shocks. In this case, $y_1(t)$ will be a linear combination of, among others, innovations in the omitted variable, and the estimates will assign spuriously to $y_1(t)$ predictive power for changes in $y_2(t)$" (Maćkowiak, 2006a).

In our model, the vector of domestic variables $y_1(t)$ consists of a measure of real activity, a measure of the aggregate price level, and exchange rate with the EU. As we have relatively short data series for Ukraine, we include only these variables for Ukraine's economy, to save degrees of freedom by estimating a small-scale VAR (see Maćkowiak, 2006a). The choice of such variables as measures of real activity and the aggregate price level is natural for the purposes of the analysis, as these variables are generally considered essential in macroeconomics and are included in many textbook models. In particular, we use real GDP and CPI inflation rate. Consumer price index is a measure of aggregate price level and is of central interest to the National Bank of Ukraine that aims to achieve and maintain the price stability in the country. We also include short-term interest rate and nominal bilateral exchange rate (UAH/EUR) in the 'domestic' block. Interest rate accounts for domestic monetary policy, as it is the main tool of the National Bank of Ukraine. The necessity of inclusion of the exchange rate can be explained by the nature of this variable, as it is important for the transmission of any shock (Cushman & Zha, 1997), and it is introduced to account for the effects of the monetary shocks on the value of the domestic currency (Kim & Roubini, 2000). Moreover, the inclusion of the exchange rate proved to be important for modelling dynamics of Ukraine's inflation (see Leheyda 2005, Kirchner et al. 2008). Accordingly, there are four domestic variables in total.

The vector of external variables $y_2(t)$ contains three kinds of variables, as we include three external shocks to identify their nature and impact on Ukraine. These are a supply shock, an international trade shock, and a foreign monetary shock. The first external shock accounts for a supply shock and is proxied by prices of two main groups of commodities traded in the world market: fuel and non-fuel price indices. To save degrees of freedom we use All Commodity Price Index, which includes both fuel and non-fuel categories of goods. Changes in commodity prices are expected to explain inflationary or deflationary pressures in Ukraine, as its growth during previous decade was mostly dependent on export prices of metals and other commodities and cheap import of fuels from Russia during 2000's (see Kirchner et al. 2008, Sutela 2012). At the same time, fuels compose a significant part of Ukraine's imports, in particular, petroleum gases and refined petroleum; see Appendix A for the stylised facts about Ukraine. The trade shock is proxied by the EU GDP shock and Russia's GDP shock. Economic growth of Ukraine still largely depends on exports to the neighbouring developed countries, especially the EU and

Russia, as they are the main trade partners of Ukraine (see Appendix A). The third external shock captures the transmission of foreign monetary policy. Accordingly, we include short-term interest rates for the EU and Russia, which are expected to account for the possibility that monetary policy decisions in Russia or the eurozone can be a source of macroeconomic fluctuations in Ukraine. Besides, we include a measure of inflation for the EU and Russia, as it is a key variable for any model. Thus there are seven external variables in total.

Accordingly, our model includes the following variables. Each block of the EU, Russia, and Ukraine includes three domestic variables measuring real activity, inflation and the interest rate. Additionally, Ukrainian block also includes the exchange rate between hryvnia and euro. We do not include the exchange rate for Russia to save degrees of freedom. Commodity prices also enter the system. A summary of the variables, their filters and abbreviations are presented in Table 2.

Table 2: Variables included in the SVAR model

Variable	Definition	Abbreviation
Commodity prices	All Commodity Price Index, 2005=100, logs	CP
EU (19)		
Output	Gross Domestic Product (real), logs	GDP_{EU}
Inflation	Consumer Price Index, logs	INF_{EU}
Interest rate	Short-term interest rates, percent	I_{EU}
Russia		
Output	Gross Domestic Product (real), logs	GDP_{RUS}
Inflation	Consumer Price Index, logs	INF_{RUS}
Interest rate	Short-term interest rates, percent	I_{RUS}
Ukraine		
Output	Gross Domestic Product (real), logs	GDP_{UA}
Inflation	Consumer Price Index, logs	INF_{UA}
Interest rate	Short-term interest rate, percent	I_{UA}
Exchange rate	UAH / EUR, logs	E_{UA}

Source: IMF, OECD, State Statistics Service of Ukraine, National Bank of Ukraine.
Note: The table presents a summary of the key variables included in the SVAR model, their filters, and abbreviations.

3.3.3 Identification scheme

The identification of the structural form of an SVAR model requires imposing restrictions. We employ so-called an AB type of SVAR model. The A matrix defines contemporaneous links between the variables. The restrictions for the A matrix are presented in Table 3 and are discussed below. The B matrix defines long-term dependencies and in this study is set as a diagonal with no extra restrictions. Accordingly, we impose short and long runs restrictions and exogeneity assumptions. Following Cushman & Zha (1997), Kim & Roubini (2000) and Dungey & Fry (2003), we impose the following constraints.

Table 3 presents the contemporaneous and lag structure of the A matrix, i.e., the variables entering into each equation. The restrictions for each row (equation) must be consistent with the block exogeneity restriction and reflect information from economic theory and empirical research. The rows in Table 3 correspond to the dependent variable in each equation and a (*) indicates the inclusion of explanatory variables in a particular equation, while a (**) indicates the inclusion of just second lag for the lagged variables. The columns indicate which of the variables are included as explanatory variables in each equation. For example, the EU's GDP contemporaneously depends on itself, world commodity prices, EU's inflation, and interest rate. There are 184 contemporaneous restrictions. As there are $2M^2$ elements in total in the structural form matrices, and the maximum number of identifiable parameters in these matrices is $M(M + 1)/2$, we need to impose $2M^2 - \frac{M(M+1)}{2} = 176$ restrictions for exact identification.

First of all, we impose block exogeneity between the economies in both the contemporaneous and dynamic structures of the model. The EU is considered as a large economy; accordingly, it is set block exogenous to both Russia and Ukraine. The economy of Russia is influenced by the economy of the EU, but is block exogenous to the Ukrainian economy, while Ukraine as a small open economy, does not influence either the EU or Russian economies. This structure is determined by shares of the countries in their foreign trade and is supported in the literature (see Bazhenova, 2012, or Appendix A for more details). The placement of Russia in the centre of the system is consistent with evidence that EU shocks are transmitted to Russia, and Russian shocks are transmitted to Ukraine, but that Russian shocks do not transmit to the EU, and Ukrainian shocks do not transmit to Russia. The logic behind imposing such restrictions is similar to the reasoning of Dungey & Fry (2003) for the analysis of the impact of shocks from the US and Japan on the Australian economy.

Table 3: Contemporaneous and lag structure of the A matrix

Dep. Var.	Explanatory variables										
	EU				Russia			Ukraine			
	CP	GDP_{EU}	INF_{EU}	I_{EU}	GDP_{RUS}	INF_{RUS}	I_{RUS}	GDP_{UA}	INF_{UA}	I_{UA}	E_{UA}
CP	1										
GDP_{EU}	*	1	**	**							
INF_{EU}	*		1								
I_{EU}		**	**	1							
GDP_{RUS}	*	**			1	**	**				
INF_{RUS}	*					1					
I_{RUS}					**	**	1				
GDP_{UA}	*				**			1	**	**	**
INF_{UA}	*			**			**	**	1	**	*
I_{UA}								**	**	1	*
E_{UA}	*	*	*	*	*	*	*	*	*	*	1

Note: The table depicts the contemporaneous and lag structure of the A matrix (B matrix is just a diagonal), i.e. the variables entering into each equation. The rows correspond to the dependent variable of each equation, while the columns indicate which of the variables are included as explanatory variables in each equation. A (*) indicates the inclusion of an explanatory variable. A (**) indicates the inclusion of an explanatory variable with a one-period lag. CP – consumer prices, GDP_{EU} – the EU's GDP, INF_{EU} – the EU's inflation, I_{EU} – the EU's interest rate, GDP_{RUS} – Russia's GDP, INF_{RUS} – Russia's inflation, I_{RUS} – Russia's interest rate, GDP_{UA} – Ukraine's GDP, INF_{UA} – Ukraine's inflation, I_{UA} – Ukraine's interest rate, E_{UA} – UAH/EUR exchange rate.

In the 'foreign' block, we set the following restrictions for commodity prices and variables of the EU and Russia. Following the idea of block exogeneity, we assume that commodity prices are not contemporaneously affected by any other variable.

Next, we define structural equations for the economy of the EU (eurozone). We assume that the EU's real output (GDP_{EU}) is contemporaneously related to world commodity prices, while it reacts to eurozone inflation and interest rates just with a one-period lag. As fuels, especially oil, are an essential input for most sectors of the economy, commodity prices are assumed to affect EU's inflation (INF_{EU}) contemporaneously. The structural equation for the EU's interest rate (I_{EU}) represents the monetary policy reaction function of the ECB. The ECB sets the interest rate on the basis of the current price level by considering "whether inflation is expected to be in line with levels consistent with its quantitative definition of price stability"[4]. We follow Kim & Roubini (2000) and assume that the ECB sets the interest rate after observing the current value of commodity prices, as well as some other variables that

[4] Cœuré, B. (2012)

we do not include in the model, but not the current values of output or the price level due to information delays that do not allow the CB to respond within the period (a month, as we have data in monthly frequency) to developments in these variables. In other words, data on prices of commodities are available within the month, while data on output and price level are not. We include commodity prices to the monetary policy reaction function of the ECB to account for inflationary shocks in the global economy and to get systematic responses to (negative) supply shocks and inflationary pressure (see Rusnák et al., 2011).

As we assume that variables from Russia have no effect on commodity prices or variables from the EU, we set the restrictions for the Russian economy in the following way. We assume that Russia's real output (GDP_{RUS}) responds to inflation and interest rate only with a one-period lag, as it generally takes some time for firms to react to changes in dynamics of these variables. Commodity prices are assumed to affect the real sector contemporaneously. We also include lagged effects from the EU's output. Analogously to the EU (19), commodity prices are assumed to affect Russia's inflation (INF_{RUS}) contemporaneously. Besides, commodity prices represent import prices to Russia and export prices to Ukraine, and export price inflation is generally found to be highly important for Ukraine (see Leheyda 2005, IMF 2005, 2008, Kirchner et al. 2008). The structural equation for Russia's interest rate (I_{RUS}) represents the monetary policy reaction function of the bank of Russia. Analogously to the monetary policy reaction function of the ECB, we assume that the bank of Russia sets the interest rate after observing the current value of commodity prices, but not to the current values of output or the price level due to information delays, as they do not allow the central bank to respond within the period (a month) to output and price level developments both in Russia and the EU. Even though data on the EU's interest rate is likely to be available within a month, we do not include it in the monetary policy reaction function of the bank of Russia. The reason is that within the period monetary authority is more concerned about changes in oil prices or non-fuel commodities, rather than the EU's interest rate. Therefore, the inclusion of contemporaneous relations with commodity prices enables the model to account for inflationary shocks in the global economy.

Finally, we define structural equations for the economy of Ukraine. We assume that real output (GDP_{UA}) responds to inflation, interest and exchange rates, only with a one-period lag, as it generally takes some time for firms to react to changes in dynamics of these variables. Commodity prices are assumed to affect the real sector contemporaneously. We also include lagged effects to Russia's output due to its importance in the international trade of Ukraine, but we do not include the EU's output to avoid multicollinearity because of some form of a common international business cycle (for more details see Dungey & Fry, 2003). Analogously to the restriction for the EU and Russia, commodity prices are assumed to affect Ukraine's inflation (INF_{UA}) contemporaneously. The structural equation of Ukraine's interest rate (I_{UA}) represents the monetary policy reaction function of the domestic central bank (the NBU). Following Sims & Zha (1997) and Kim & Roubini (2000), we assume that the NBU sets the interest rate after observing the current value of commodity prices and the exchange rate, but not to the current values of output or the price level due to information delays. We include commodity prices and the exchange rate to the monetary policy reaction function of the NBU to account for inflationary shocks in the global economy. In particular, the inclusion of commodity prices allows obtaining systematic responses from the monetary policy reaction function to (negative) supply shocks and inflationary pressure. The inclusion of the exchange rate is required by the specifics of Ukraine's economy and the NBU operation, as starting from early years of Ukraine's independence, monetary authorities were concerned about the impact of currency depreciation on the level of inflation. Moreover, the inclusion of the exchange rate should help us to account for the impact of external shocks through import prices. Finally, as the exchange rate (E_{UA}) is a forward-looking asset price, we assume that it reacts to all variables contemporaneously (see Buckle 2007, Kim & Roubini 2000, Dungey & Fry 2003).

3.2 Data

We use monthly data over the period January 2003 - December 2016 (168 observations) to include the main economic episodes that have characterised the process of development of Ukraine's economy but excluding severe economic volatility of the 1990s. The starting point of the data set, January 2003, is chosen because of data availability for real GDP of Russia. However, in order to check if the conflict with Russia and political crisis in 2014 have lead to fundamental changes of links in the economy of Ukraine or bigger importance of the external factors, we replicate our estimations over the period till December 2013 and present the results in Appendix D.

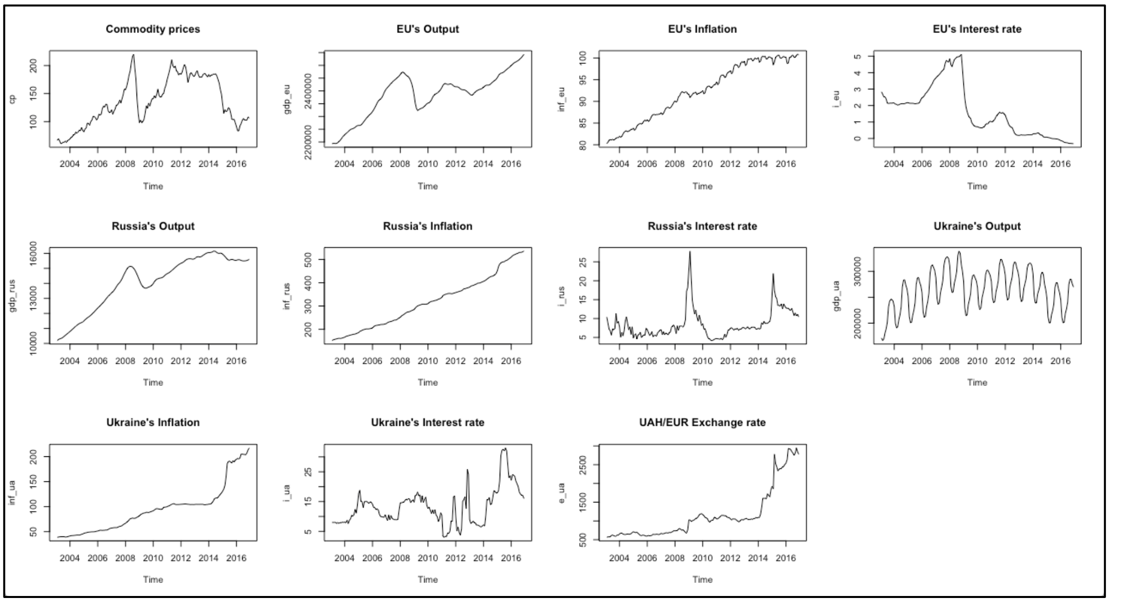
Data are taken from IMF, Eurostat, OECD, the Federal Service for State Statistics (Rosstat), the State Statistics Service of Ukraine, the National Bank of Ukraine. For the EU's variables, we use aggregated data over 19 countries that are part of the eurozone. Data sources and codes can be found in Appendix B. Descriptive statistics of data before transformations are presented in Table 4, while the plot of data is presented in Figure 2.

All data series show high volatility during periods of economic or political instability. Therefore, we detect outliers in each time series using Multivariate Model Approach (Cook's Distance) and replace them by predictive mean matching employing MICE (Multivariate Imputation by Chained Equations). Moreover, time series of inflation of the EU and Russia as well as Ukraine's GDP show a clear seasonal pattern, so we remove seasonality and check the rest of time series for the presence of seasonality.

Even though the studies discussed before mostly use quarterly data, we choose monthly frequency due to a short period of available data and data availability mostly in this frequency. The only types of time series that are not available in monthly frequency are GDP for all three countries; they are available only in quarterly or annual frequency. Therefore, we use a technique of cubic spline interpolation to transform this data to higher frequencies.

Following Rusnák et al. (2011), we include GDP gaps instead of real GDP for all three economies to account for potential output and avoid price puzzle in impulse responses. We obtain output gap from real GDP in logarithms using the Hodrick–Prescott filter to remove the cyclical component of a time series from raw data.

Figure 2: Plot of data



Source: Author's calculations

Note: The figure shows the plot of data series for 11 variables used for the analysis. Data is before transformation and plotted against time. The first row (from left): commodity prices, EU's output, EU's inflation, EU's interest rate. The second row (from left): Russia's output, Russia's inflation, Russia's interest rate, Ukraine's output. The third row (from left): Ukraine's inflation, Ukraine's interest rate, UAH/EUR exchange rate.

Table 4: Descriptive statistics of data used for the SVAR estimation

	Mean	Median	Min	Max	Stand dev.	Skew	Kurto sis	Obser- vations
CP	135.17	129.43	60.69	220.03	42.59	0.05	-1.23	167
GDP_{EU}	2384589	2404439	2193597	2549423	86518.2	-0.55	-0.41	167
INF_{EU}	92.47	92.20	80.26	101.31	6.57	-0.27	-1.31	167
I_{EU}	1.63	1.37	-0.32	5.11	1.53	0.68	-0.57	167
GDP_{RUS}	14094.84	14615.97	10198.72	16149.42	1764.65	-0.78	-0.69	167
INF_{RUS}	318.68	312.55	152.20	537.80	111.77	0.32	-0.97	167
I_{RUS}	8.48	7.40	4.20	27.83	3.76	2.03	5.51	167
GDP_{UA}	262987	267629	166763	338937	38353.3	-0.28	-0.61	167
INF_{UA}	94.46	92.50	38.70	219.26	47.73	1.06	0.41	167
I_{UA}	13.26	12.54	3.01	33.00	6.15	1.04	1.31	167
E_{UA}	1154.27	1026.06	564.49	2947.28	667.48	1.52	1.10	167

Source: IMF, OECD, State Statistics Service of Ukraine, National Bank of Ukraine.

Note: The table presents descriptive statistics of data before transformations. CP – consumer prices, GDP_{EU} – the EU's GDP, INF_{EU} – the EU's inflation, I_{EU} – the EU's interest rate, GDP_{RUS} – Russia's GDP, INF_{RUS} – Russia's inflation, I_{RUS} – Russia's interest rate, GDP_{UA} – Ukraine's GDP, INF_{UA} – Ukraine's inflation, I_{UA} – Ukraine's interest rate, E_{UA} – UAH/EUR exchange rate.

For all variables, we use the series in the first difference to achieve stability of the VAR (SVAR) system. Accordingly, we lose one observation at the beginning of the sample. All the time series except interest rates are transformed to logarithms before differencing. The stationarity of variables is tested using the ADF unit root test procedure, as well as KPSS and PP tests due to their different specification. For all series, if the ADF test is applied, the null hypothesis of a unit root cannot be rejected at 1% level of significance, while for their first differences it can be rejected at 1% level of significance mostly. After differencing, we again test the stationarity of variables using the unit root tests. As we can see from Table 5, results of the tests differ for such variables as GDP and the interest rates, which according to the PP test seem to be stationary in levels. The results of the tests may differ because of the high volatility of data during periods of crisis. Nevertheless, we replicate the estimation with the interest rates in levels as a sensitivity analysis.

Table 5: Tests for stationarity

	ADF		KPSS		PP	
	level	Δ	level	Δ	level	Δ
CP	0.6949	< 0.01	< 0.01	> 0.1	0.7808	< 0.01
GDP_{EU}	0.4381	0.1128	< 0.01	> 0.1	0.8438	0.04011
INF_{EU}	> 0.99	< 0.01	< 0.01	> 0.1	0.8276	< 0.01
I_{EU}	0.3878	0.04201	< 0.01	> 0.1	0.8017	< 0.01
GDP_{RUS}	0.6677	0.02503	< 0.01	< 0.01	0.966	0.1116
INF_{RUS}	0.9542	< 0.01	< 0.01	> 0.1	0.9444	< 0.01
I_{RUS}	0.2024	< 0.01	< 0.01	> 0.1	0.03553	< 0.01
GDP_{UA}	0.3726	< 0.01	< 0.01	0.01729	0.7476	< 0.01
INF_{UA}	0.9578	< 0.01	< 0.01	> 0.1	> 0.99	< 0.01
I_{UA}	0.2207	< 0.01	< 0.01	> 0.1	0.08406	< 0.01
E_{UA}	0.9822	< 0.01	< 0.01	> 0.1	0.952	< 0.01

Source: Author's calculations.

Note: The table presents results of the tests for unit root for data in levels and after first differencing. The null hypothesis of the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests is that data a time series sample has a unit root, i.e., data is not stationary. The null hypothesis of the KPSS test is that a time series sample is level or trend stationary. CP – consumer prices, GDP_{EU} – the EU's GDP, INF_{EU} – the EU's inflation, I_{EU} – the EU's interest rate, GDP_{RUS} – Russia's GDP, INF_{RUS} – Russia's inflation, I_{RUS} – Russia's interest rate, GDP_{UA} – Ukraine's GDP, INF_{UA} – Ukraine's inflation, I_{UA} – Ukraine's interest rate, E_{UA} – UAH/EUR exchange rate.

4 Empirical Results

4.1 Estimation and stability tests

In this section, we are going to provide with the details of the model estimation and conducted stability tests; present the results from the impulse responses and forecast error variance decomposition; discuss the robustness of the results and suggest policy implications. The main purpose of the empirical analysis is to examine external sources of macroeconomic variability in Ukraine, and in so doing, to differentiate between the effects of different external shocks, in particular from the EU and Russia.

We begin by estimating a reduced form VAR model for $y_t = [y_{1,t}, y_{2,t}]'$ over the sample period (February 2003 – December 2016). The vector $y(t)$ includes both 'domestic' and 'foreign' blocks and is created by including $y_1(t)$ and $y_2(t)$ as columns over each month in time across the sample. We estimate the reduced form VAR model by OLS in first differences in order to ensure stationarity as we do not find evidence that the variables are co-integrated. Following Rusnák et al. (2011), we include GDP gaps instead of real GDP for all three economies to account for potential output and avoid price puzzle in impulse responses[5].

Before running the model, we examine the fit of the reduced form VAR model for a different number of lags *(p)* only with a constant term being included, i.e. an intercept in each equation of the model. Deciding about the lag length, we rely on tests for misspecification, with the main goal to remove serial autocorrelation and ARCH-effects from the residuals. Akaike information criterion and Akaike's Final Prediction Error criterion suggest $p=12$, while Schwarz and Hannan–Quinn criteria suggest including only one lag. So, we run the VAR model setting alternatively $p = 1, 2, 3, 6, 12$ and compare the Laplace approximation to the log marginal likelihood, as well as stability and other properties of the model. We find that the specification with only two lags ($p=2$) included achieves the best fit and leaves no serial correlation in residuals. Moreover, the inclusion of more lags does not further improve the residuals and taking into account relatively short sample we have at disposal, higher lags order would be implausible due to degrees of freedom considerations. Therefore, in

[5] An alternative specification with a real GDP included for all three countries leads to price puzzle: an increase of domestic inflation after a positive shock of the domestic short-term interest rate.

subsequent analysis, we focus on the specification with two lags. However, we check whether the results of the analysis are robust with respect to the choice of the number of lags. In the next step, we impose lag restrictions in accordance with Table 3, so as for some variables only the second lag is included.

We investigate the stability of the reduced form VAR model, the presence of serial correlation in the residuals from the estimated reduced form VAR model as well as their homoscedasticity and normality. The results of the misspecification tests are presented in Appendix B. All unit roots are within the unit circle; hence, the system is stable. Regarding residuals, the Portmanteau test does not indicate the presence of serial correlation, while the Jarque-Bera test indicates that residuals do not come from normal distribution and ARCH test indicates their heteroscedasticity. Non-normality of residuals implies that computed t-statistics are not valid. Heteroscedasticity affects only standard errors, but not the actual value of the estimate. As we are interested in the actual value of the estimate and are aware of the side effect of the abovementioned issues, we consider them acceptable.

The structural VAR model is estimated by minimising the negative of the concentrated log-likelihood function, using the variance-covariance matrix of the reduced form VAR model estimated in the previous step and the restrictions imposed for the structural form, which were introduced in the previous section (see 3.3.3 Identification scheme) and can be found in Table 3. The structural VAR model was estimated by numerical optimisation methods that directly minimise the negative log-likelihood. The system is over-identified with eight over-identifying restrictions, so we check a formal likelihood ratio test.

4.2 Impulse Responses

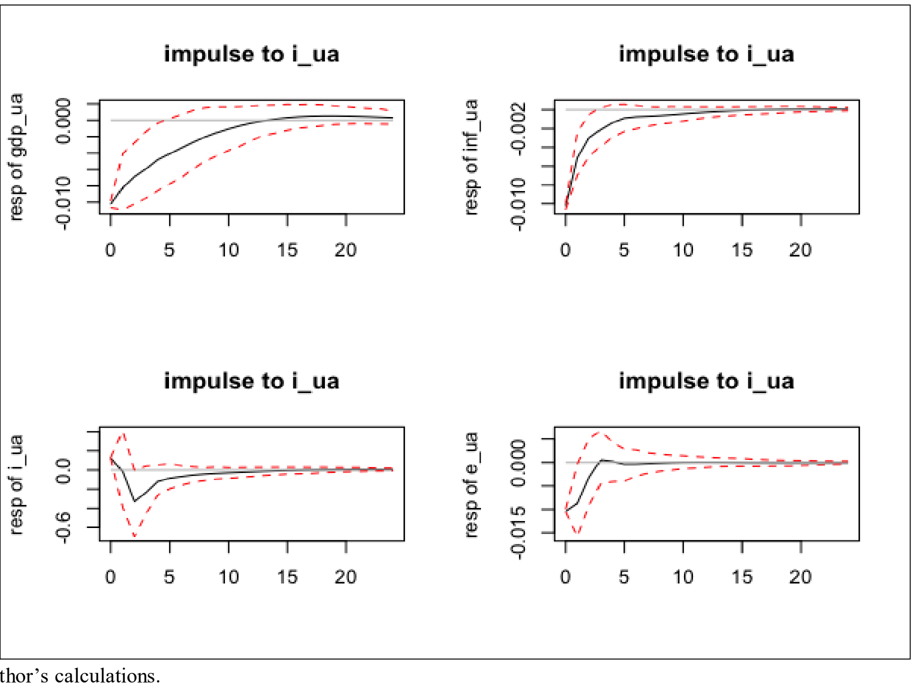
We begin the investigation of model dynamics by looking at the orthogonal impulse response functions based on the structural VAR model presented in Section 3. The impulse response function serves to track the reaction of one of the variables from the model to a one-time shock (an impulse) within its dynamic system at the time of the shock and over subsequent points in time. Accordingly, the orthogonal impulse response function represents the impact of a one-time shock to the variables from the model at a single point in time. The impulse responses are plotted with 95% confidence bands, which were bootstrapped using 500 replications.

We want to know how variables from both ‘domestic’ and ‘foreign’ blocks respond to exogenous shocks. In particular, we are interested in the effects of output and monetary policy shocks from the EU and Russia on output and prices in Ukraine.

Nevertheless, it is important to test whether the model is able to provide with sensible dynamics, apart from the impacts of foreign shocks on the economy of Ukraine.

So we start with inspecting whether the domestic monetary policy shock results in expected changes in other domestic variables and we look at the effects of a one-time interest rate shock on real GDP and the price level. Usually, we would expect real GDP and the price level to fall after a positive interest rate shock. Figure 3 shows the impact of the domestic monetary policy shock on the nominal interest rate itself, domestic real GDP, prices and UAH/EUR exchange rate. We can observe a decrease in real GDP in response to a domestic monetary policy shock. The response of real GDP is equal to zero after thirteen months from the shock. However, the results are statistically significant only for the first four months. A decrease in real GDP is followed by a fall in inflation. We do not observe prise puzzle, i.e. increase of inflation in the medium and long run after a positive interest rate shock. Even though it is often detected in VAR models (see Rusnák et al., 2011), we manage to eliminate price puzzle by the inclusion of the output gap[6].

Figure 3: Responses of Ukrainian variables to a domestic interest rate shock



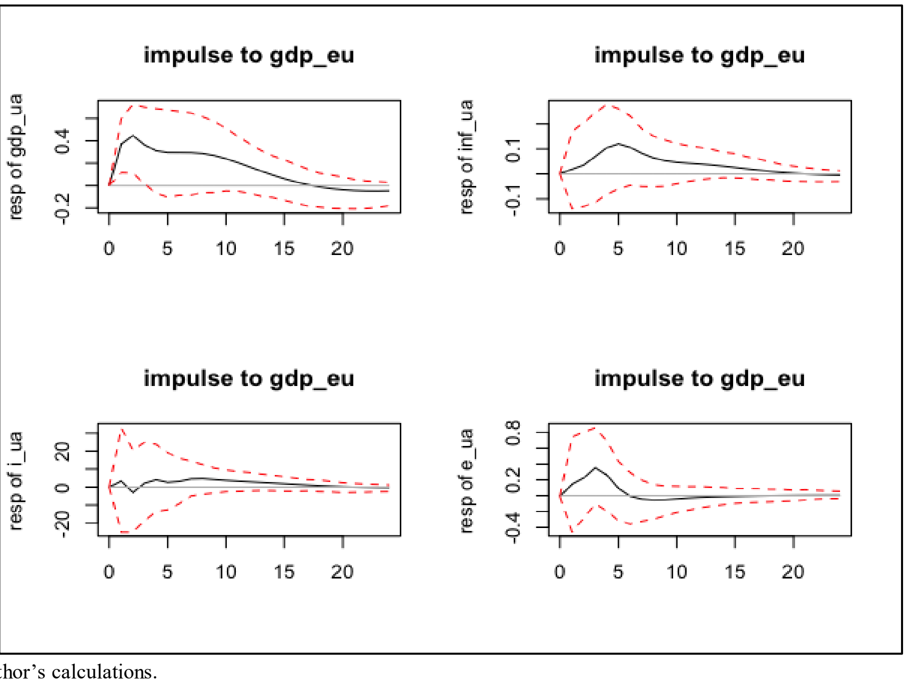
Source: Author's calculations.
Note: The figure presents impulse responses of Ukraine's GDP (gdp_ua), inflation (inf_ua), UAH/EUR exchange rate (e_ua) and the interest rate (i_ua) itself to a positive innovation in the short-term interest rate in Ukraine (i_ua). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

[6] An alternative model specification with real GDP included for the all three countries leads to strong price puzzle in impulse responses.

Output shock from the EU (eurozone) results in mostly predictable responses of Ukrainian variables. Figure 4 shows that a eurozone output shock leads to expansions in Ukraine's real GDP. The expansion in real output, in turn, results in the higher price level with its peak around 5th month. After five months from the moment of the shock, the rise in the EU's output increases inflation in Ukraine to its highest level, primarily through import prices and the exchange rate as we mention in Section 3.3. Monetary policy is expected to react by contracting and we observe a slight increase in the nominal interest rate lasting up to 20 months, even though the response is volatile and shows a decrease in the second month.

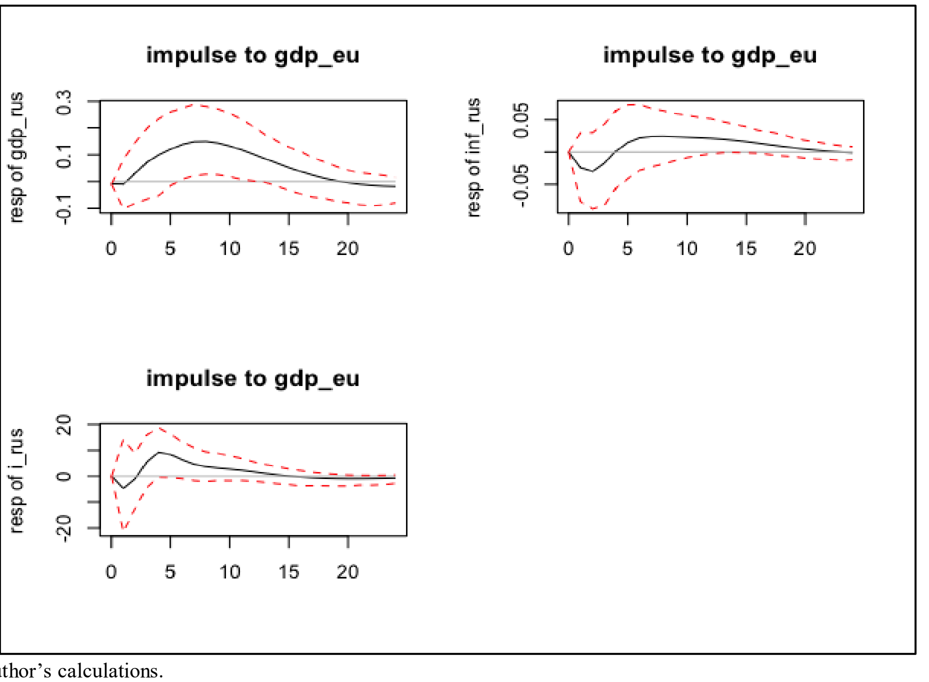
The responses of Ukrainian variables to the EU's output shocks are augmented by their transmission through the Russian economy. Figure 5 shows the expansionary effects of the EU's output shock on Russia's real GDP. The increase in Russia's output is accompanied by an increase in the inflation rate, although we observe a slight decrease during the first four months after the shock. It is followed by contractionary monetary policy in Russia in reaction to the EU's output expansion, although during the first month after the EU's output shock we observe a decrease in the nominal interest rate, which probably reflects similar dynamics in Russian inflation.

Figure 4: Responses of Ukrainian variables to the EU's GDP shock



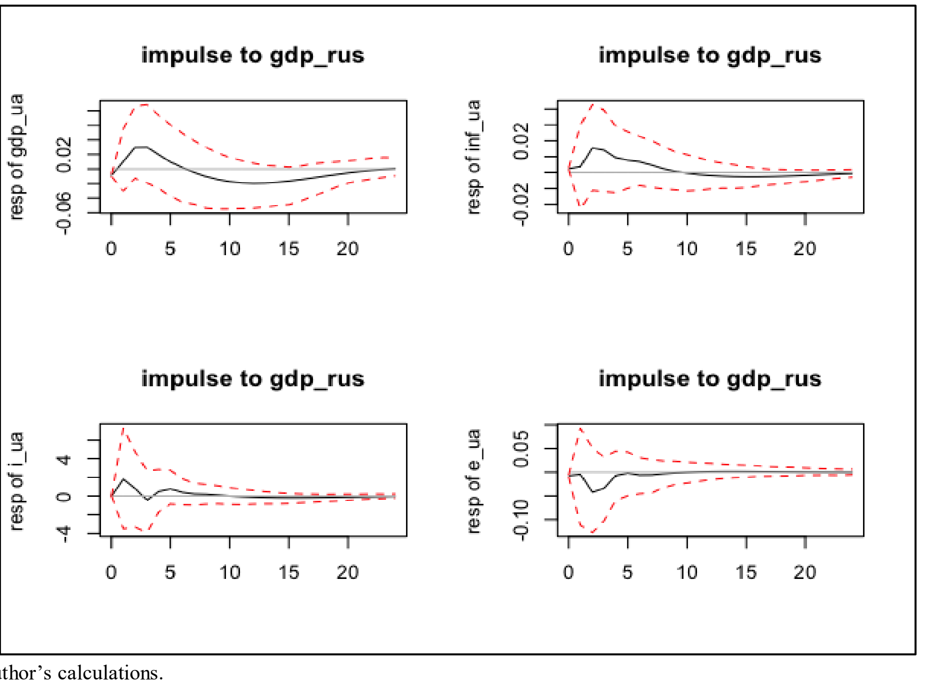
Source: Author's calculations.
Note: The figure presents impulse responses of GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) of Ukraine to a positive innovation in the real GDP in the EU (gdp_eu). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands ((dashed lines)), which were bootstrapped using 500 replications.

Figure 5: Responses of GDP, inflation and interest rate of Russia to the EU's GDP shock



Source: Author's calculations.
Note: The figure presents impulse responses of GDP (gdp_rus), inflation (inf_rus) and interest rate (i_rus) of Russia to a positive innovation in the real GDP in the EU (gdp_eu). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 6: Responses of Ukrainian variables to Russia's GDP shock

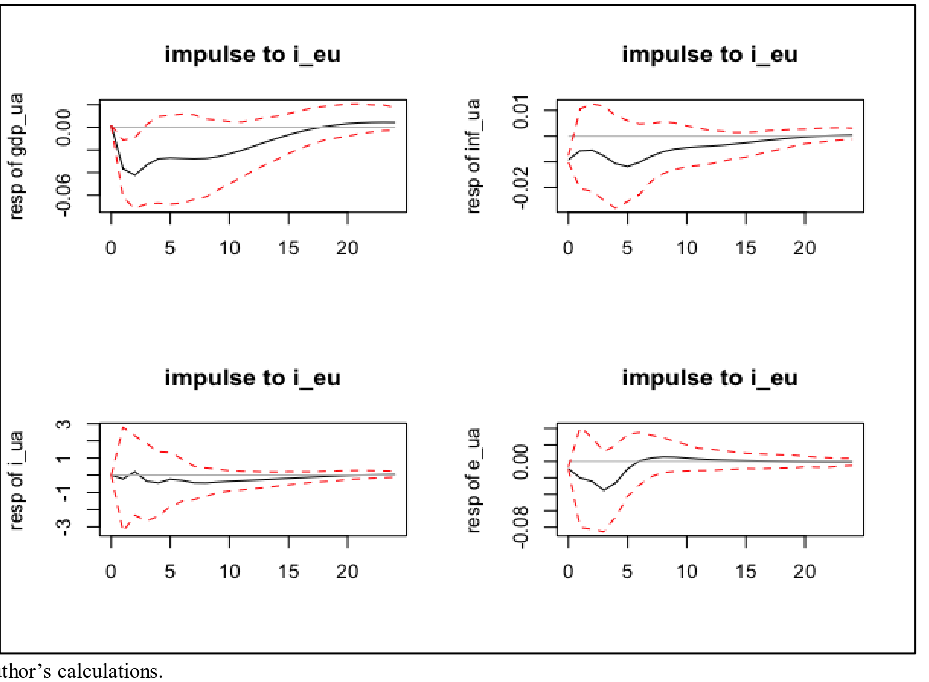


Source: Author's calculations.
Note: The figure presents impulse responses of GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) of Ukraine to a positive innovation in the real GDP in Russia (gdp_rus). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Analogously, Russia's output shock results in expansion of Ukraine's GDP and inflation with the peak around 3rd month, and accordingly, contractionary monetary policy reaction, even though the reaction of Ukraine's interest rate is quite volatile after the shock. In contrast to the EU's output shock, Ukrainian currency responds by slight appreciation. Figure 6 presents the responses.

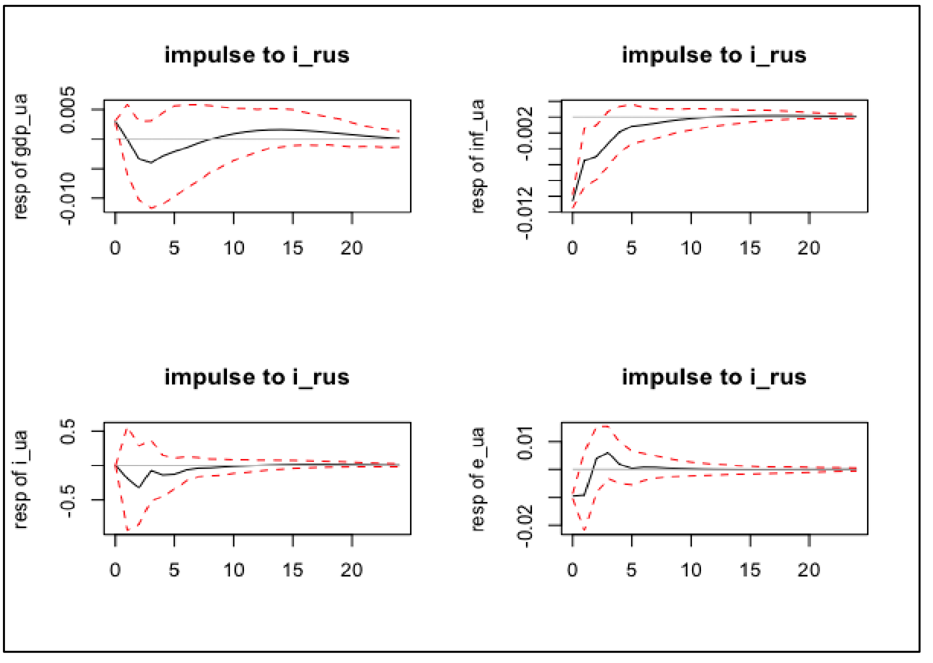
Responses of Ukrainian variables to international monetary policy shocks are presented in Figure 7 for the shock originating in the eurozone and in Figure 8 for a monetary policy shock from Russia. Inspection of Figure 7 reveals that a contractionary shock in eurozone leads to an expected decrease in Ukraine's real output and lower inflation. The reaction of the interest rate is unclear. Similarly to a eurozone monetary policy shock, an increase in Russia's interest rate (Figure 8) leads to a contraction in Ukraine's real output, followed by lower inflation along with lower nominal interest rate. Analogously, the response of Ukraine's interest rate is volatile and unclear.

Figure 7: Response of Ukrainian variables to a shock in the EU's interest rate



Source: Author's calculations.
Note: The figure presents impulse responses of Ukraine's GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) to a positive innovation in the short-term interest rate in the EU (i_eu). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 8: Responses of Ukrainian variables to Russia's interest rate shock



Source: Author's calculations.
Note: The figure presents impulse responses of GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) of Ukraine to a positive innovation in the short-term interest rate in Russia (i_rus). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

In general, the model does not perform well in capturing the behaviour of Ukraine's monetary policy transmission. The time series for Ukraine are very noisy, making sensible estimation difficult[7]. Besides, there may be other reasons. According to Rusnák et al. (2011), these may be the level and volatility of inflation in a country and the degree of central bank independence. In periods of high inflation (that happens regularly in Ukraine), people question the credibility of the central bank, which in turn restricts its ability to affect the price level. If the central bank is not independent enough (which is probably the case of the NBU), it leads to similar problems with credibility and has similar consequences. Finally, exchange rate regime also affects the effectiveness of the monetary policy and in more open economies can amplify its impact. Ukrainian hryvnia for years had been *de facto* fixed to the US dollar that apparently did not contribute to the effectiveness of domestic monetary policy in stabilising inflation. Further comments about constraints on the transmission of policy rate changes in Ukraine can be found in an IMF staff paper (IMF, 2017).

In Figure 9 we present impulse responses from the SVAR model without Russia for the EU's interest rate shock. Compared to impulse responses from Figure 7, the

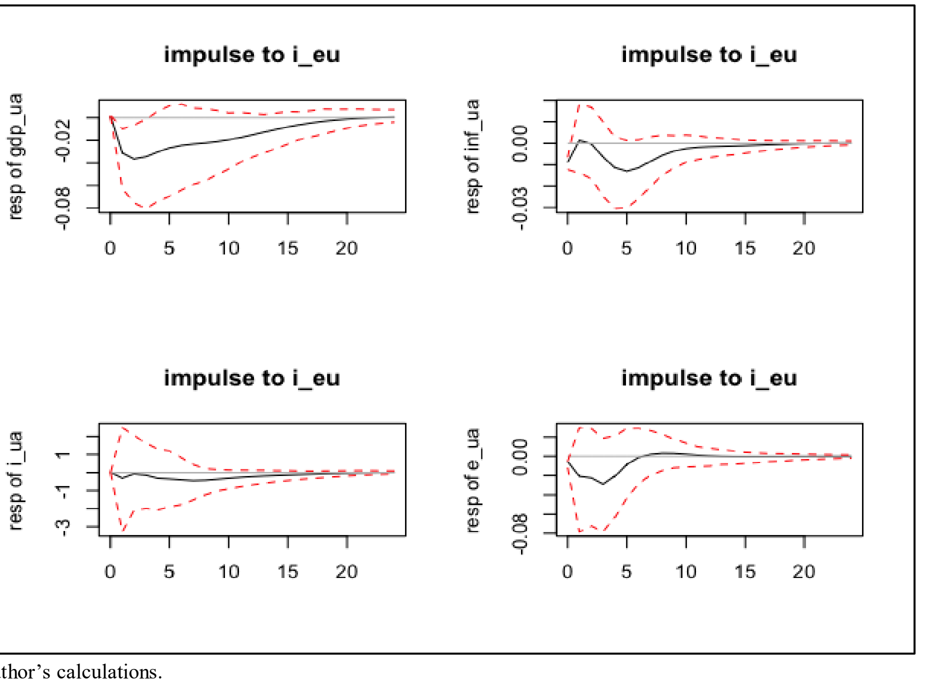
[7] We try different model specification with different data sources, but they show no improvement over the current version.

inclusion of the Russian economy reduces the amplitude of the responses of Ukrainian variables. In Figure 9, Ukraine's GDP shows a deeper and longer response to monetary contraction in the euro area. Moreover, we observe similar result for the EU's output shock (Figure 10). Therefore, the inclusion of Russia in the model is important to achieve correct model specification and avoid an overstatement of the impact of shocks originating from the EU on the Ukrainian economy.

4.3 Variance Decomposition

To quantitatively assess how important are external shocks for variation of real output and price level in Ukraine we employ Forecast Error Variance Decomposition. It is based on the orthogonalised impulse response coefficient matrices and allows analysing the contribution of one variable from a model to the forecast error variance of another variable. In other words, it allows finding the fraction of the overall fluctuations in the variables that is due to some shock, as it indicates the amount of information each variable contributes to the other variables in a model.

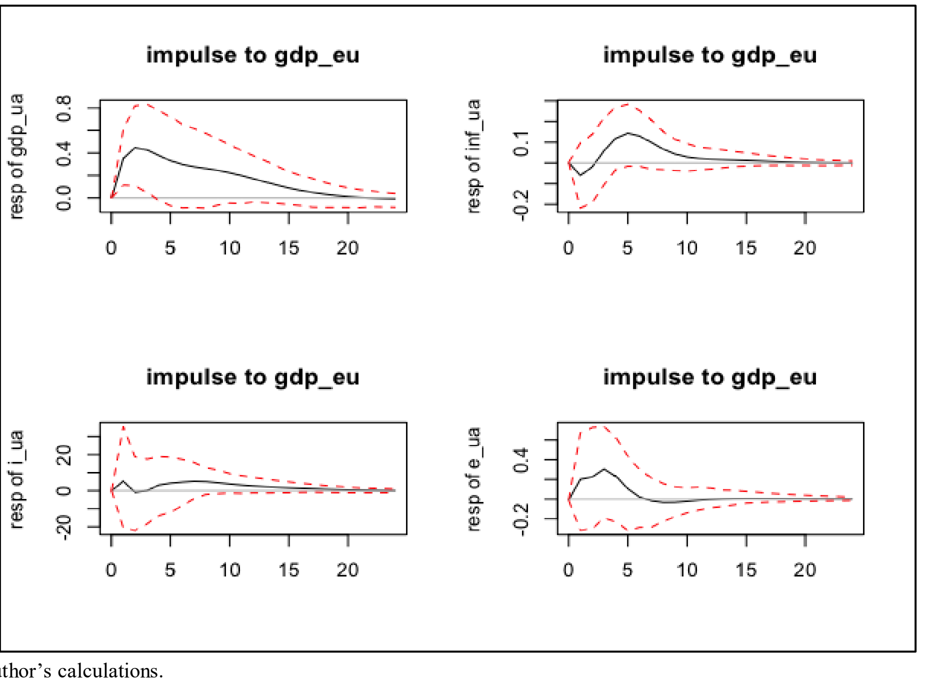
Figure 9: Responses of Ukrainian variables to the EU's interest rate shock (from the SVAR without Russia)



Source: Author's calculations.

Note: The figure presents impulse responses (from the SVAR without Russia) of GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) of Ukraine to a positive innovation in the short-term interest rate in the EU (i_eu). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 10: Responses of Ukrainian variables to the EU's output shock (from the SVAR without Russia)



Source: Author's calculations.

Note: The figure presents impulse responses (from the SVAR without Russia) of GDP (gdp_ua), inflation (inf_ua), exchange rate (e_ua) and interest rate (i_ua) of Ukraine to a positive innovation in output in the EU (gdp_eu). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Below, we present the forecast error variance decomposition of Ukrainian variables from the SVAR model. In particular, we focus on share of the variance in real output and price level in Ukraine attributable to external shocks, at horizons of 3-6 months (the short-run), 12 months (the medium run) as well as 24 months (the long-run).

In Table 6, we report the share of the variance in Ukrainian variables attributable to external shocks jointly, i.e. from world shocks proxied by commodity prices as well as all types of shocks from the EU and Russia. External shocks account for about 95-97% of the variance in real output in Ukraine in the short run. The medium-run estimate of the variance in real output attributed to externals shocks equals to about 97,8%. The long-run estimate is the highest among Ukrainian variables and is about 97,9%. The short-run estimate for inflation in Ukraine is slightly lower compared to the rest of Ukrainian variables and equals to about 28-74%, the medium-run estimate is about 84%, and the long-run estimate is about 85%. The short-run estimate for the nominal short-term interest rate in Ukraine is as high as for real output and equals to about 95%, the medium and long-run estimate is about 96%. The estimate for nominal UAH/EUR exchange rate equals to about 90-96% over the whole horizon. Thus we find that a significant share of the variation in real output, aggregate price level, the nominal short-term interest rate and nominal UAH/EUR exchange rate in

Ukraine can be attributed to external shocks. Like in other post-Soviet countries, Ukraine's GDP fell sharply after the collapse of the Soviet Union in 1991. However, the economy of Ukraine experienced rapid economic growth in 2000-2008 due to a 50% growth of exports during that period[8] and still largely depends on the international trade.

Table 6: The contribution of external shocks jointly to forecast error variances of Ukrainian variables using the SVAR

Variable	Horizon (months)			
	3	6	12	24
Ukraine's GDP	0.948538518	0.967252424	0.978061839	0.978892788
Ukraine's inflation	0.281886887	0.744989248	0.835770507	0.845771286
Ukraine's interest rate	0.953868197	0.94894522	0.962301794	0.965014154
UAH/EUR exchange rate	0.904590046	0.955621863	0.956843298	0.956947564

Source: Author's calculations.

Note: The table presents the contribution of external shocks jointly to forecast error variances of Ukraine's GDP, inflation, interest rate and UAH/EUR exchange rate at horizons of 3-6 months (the short-run), 12 months (the medium run) as well as 24 months (the long-run). External and domestic shocks add to one.

In Table 7, we report the share of the variance in Ukrainian variables attributable to each external shock separately, i.e. from commodity prices as well as real GDP, inflation and the short-term interest rate from the EU and Russia. In other words, we continue analysing the same parameters as in Table 6 but switch from analysing the total effect of external shocks to inspecting how important they are for the dynamics in Ukrainian variables. Among external shocks, output shock originating in the EU has the strongest effect on real output in Ukraine and accounts for 84-90 % in the variance with the strongest effect in the long run. The most prominent effect on inflation in Ukraine in the short run (3 months) has inflationary shock from Russia (about 10 %), while in the middle and long run the most influential is output shock from the EU (60-75%) with the strongest impact in the long run. Output shock from the EU also has the biggest effect on the nominal UAH/EUR exchange rate in Ukraine and accounts for 40-68 % in its variance, while for the nominal interest rate in Ukraine the most influential is inflationary shock from the EU, which accounts for 44-77 % with its strongest impact in the short run.

Our findings are comparable to estimates found in the literature, although our estimates are slightly higher. So, Cushman & Zha (1997) find that about 50-75% of the variance in the real aggregate output in Canada originates from external shocks. According to findings of Giordani (2004), this share is approximately 70% for the

[8] Sutela (2012)

variance in output and only 40% for the variance in inflation. Likewise, Horvath & Rusnak (2008) find that about 70% of the fluctuations in output and 80% of the fluctuations in inflation in Slovakia can be attributed to external shocks. According to results obtained by Erten (2012), more than 50% of the variation in real output growth of emerging economies in Latin America is explained by external factors, while for emerging Asia and China it is slightly less than 50%. However, Maćkowiak (2006) estimates that external shocks account for about 15-20 % of the short-run variance in real output in the Czech Republic, Poland and Hungary and 25-50 % in the long run, while estimates for inflation are bigger – 20-50 % and 60-85 % in the short run and the long run accordingly. In general, such results indicate that dynamics in output and inflation in open economies is mostly affected by external factors, which is increasing over the last decades following development in international trade and regional interdependencies.

Table 7: The contribution of each external shock separately to forecast error variances of Ukrainian variables using the SVAR

		Source of disturbance (external)						
		CP	GDP_{EU}	INF_{EU}	I_{EU}	GDP_{RUS}	INF_{RUS}	I_{RUS}
Ukraine's GDP	*3*	0.0146	**0.8365**	0.0655	0.0078	0.0026	0.0214	0.0000
	6	0.0120	**0.8526**	0.0561	0.0075	0.0032	0.0358	0.0001
	12	0.0103	**0.8929**	0.0371	0.0080	0.0028	0.0269	0.0000
	24	0.0102	**0.8952**	0.0350	0.0081	0.0042	0.0261	0.0001
Ukraine's inflation	*3*	0.0137	0.0854	0.0476	0.0079	0.0143	**0.1040**	0.0090
	6	0.0143	**0.6001**	0.0631	0.0087	0.0115	0.0438	0.0035
	12	0.0140	**0.7327**	0.0409	0.0088	0.0083	0.0288	0.0022
	24	0.0137	**0.7471**	0.0384	0.0088	0.0084	0.0272	0.0021
Ukraine's interest rate	*3*	0.0201	0.1062	**0.7729**	0.0005	0.0205	0.0331	0.0007
	6	0.0199	0.2022	**0.6711**	0.0019	0.0208	0.0324	0.0008
	12	0.0169	0.4231	**0.4777**	0.0039	0.0155	0.0247	0.0006
	24	0.0162	0.4661	**0.4397**	0.0043	0.0150	0.0230	0.0005
UAH/EUR exchange rate	*3*	0.0023	**0.3983**	0.3027	0.0060	0.0106	0.1836	0.0011
	6	0.0131	**0.6678**	0.1573	0.0076	0.0076	0.1017	0.0006
	12	0.0131	**0.6741**	0.1540	0.0076	0.0076	0.1000	0.0006
	24	0.0131	**0.6748**	0.1535	0.0076	0.0076	0.0998	0.0006

Source: Author's calculations.

Note: The table presents the contribution of each external shock separately to forecast error variances of Ukraine's GDP, inflation, interest rate and UAH/EUR exchange rate at horizons of 3-6 months (the short-run), 12 months (the medium run) as well as 24 months (the long-run). A shock with the biggest contribution over a specific horizon is marked in bold. External and domestic shocks add to one. CP – consumer prices, GDP_{EU} – the EU's GDP, INF_{EU} – the EU's inflation, I_{EU} – the EU's interest rate, GDP_{RUS} – Russia's GDP, INF_{RUS} – Russia's inflation, I_{RUS} – Russia's interest rate.

In Table 7, we also report the shares of the variance in Ukrainian variables attributable to monetary policy shocks originating from the EU and Russia relative to other shocks. According to our results, these shocks do not constitute a major source of variation in Ukrainian economy, so monetary contraction in the EU explains less than 1% of the variance in real output in Ukraine over the whole horizon, while the impact from monetary contraction in Russia is nearly zero. The effect slightly increases as the time horizon increases, but nevertheless accounts only for less than 1 % in the long run. Remarkably, foreign monetary policy shocks (both from the EU and Russia) have also almost no effect on the price level in Ukraine and account for 1,7 % of the variance at most (in the short run). The interest rate shock from the EU accounts for 0,79-0,88% of the variance in inflation over the whole horizon. Meanwhile, the interest rate shock from Russia accounts for about 0,9% of the variance in the short run, but the effect gradually decreases to about 0,2% in the long run.

4.4 Robustness of the Results

As the last step of the analysis, we conduct sensitivity check of the results. In other words, we want to check how sensitive the results are to a different identification scheme, the inclusion of time series for the short-term interest rates in levels and two different indices of commodity prices. The obtained results are presented in Appendix D. In particular, we focus on the impulse responses and forecast decompositions obtained from different model specifications and compare them to the results described in the previous subsection. In the end, we find that sensitivity check does not lead to considerably different results than the ones presented in the main text.

First, we use a different identification scheme to estimate the model, so-called Choleski recursive scheme, so the A matrix of the SVAR is a lower triangular (Table 9). To keep a block exogeneity restriction, we order the variables of each considered country as follows: a measure of real output, inflation, interest rate and the exchange rate (only for Ukraine). As we assume that commodity prices should not be affected by any other variable within the system, this variable is put in the first place. In Appendix D, we present the impulse responses of Ukrainian variables to foreign monetary policy (from both the EU and Russia) shocks. The results are very similar to the baseline specification.

Table 8: Structure of the A matrix as Choleski recursive scheme

Dep. Var.	Explanatory variables										
	EU				Russia			Ukraine			
	CP	GDP_{EU}	INF_{EU}	I_{EU}	GDP_{RUS}	INF_{RUS}	I_{RUS}	GDP_{UA}	INF_{UA}	I_{UA}	E_{UA}
CP	1										
GDP_{EU}	*	1									
INF_{EU}	*	*	1								
I_{EU}	*	*	*	1							
GDP_{RUS}	*	*	*	*	1						
INF_{RUS}	*	*	*	*	*	1					
I_{RUS}	*	*	*	*	*	*	1				
GDP_{UA}	*	*	*	*	*	*	*	1			
INF_{UA}	*	*	*	*	*	*	*	*	1		
I_{UA}	*	*	*	*	*	*	*	*	*	1	
E_{UA}	*	*	*	*	*	*	*	*	*	*	1

Note: The table depicts the structure of the A matrix as Choleski recursive scheme (B matrix is just a diagonal), i.e. the variables entering into each equation. The rows correspond to the dependent variable of each equation, while the columns indicate which of the variables are included as explanatory variables in each equation. A (*) indicates the inclusion of an explanatory variable. CP – consumer prices, GDP_{EU} – the EU's GDP, INF_{EU} – the EU's inflation, I_{EU} – the EU's interest rate, GDP_{RUS} – Russia's GDP, INF_{RUS} – Russia's inflation, I_{RUS} – Russia's interest rate, GDP_{UA} – Ukraine's GDP, INF_{UA} – Ukraine's inflation, I_{UA} – Ukraine's interest rate, E_{UA} – UAH/EUR exchange rate.

Second, we include time series for the short-term interest rates in levels, i.e. do not first difference time series of the short-term interest rate of the EU, Russia and Ukraine. There is a range of studies that questioned the presence of a unit root in the nominal interest rate if standard test for unit root are used (for more details see Clemente et al., 2017). Nevertheless, the impulse responses and forecast decomposition are similar to the ones obtained from the baseline model.

Last, we replace All Commodity Price Index used in the baseline specification by two different indices of commodity prices – Metals Price Index and Crude Oil Price Index, both in constant prices (2005=100) and retrieved from IMF. The reasons explaining why All Commodity Price Index is optimal as well as why the other two indices might be important can be found in Subsection 3.3.2. We run the model one by one with each index and compare the results from the impulse responses. Similarly to the first part of sensitivity check, the inclusion of a different index does not change the results significantly. The impulse responses look similar to the ones obtained from the baseline model. In addition, we also check the robustness of the results from the forecast error variance decomposition. In the end, the inclusion of a different commodity price index does not bring considerable changes to the results.

Commodity prices still explain only tiny share of the variance in real output and prices in Ukraine[9].

4.5 Policy implications

Finally, we provide with some suggestions on the question of the appropriate policy response to the types of external shocks analysed in this work, in particular focusing on exchange rate regime and fiscal policy.

Our findings support the view of Feldkircher (2013), who considers Ukraine as one of the economies most vulnerable to all sorts of foreign shocks. Therefore, in light of the adoption of the IT regime by Ukraine starting from 2017, our results suggest that the National Bank of Ukraine should closely track external developments to achieve inflation targets. Moreover, international variables be explicitly included in both optimal and actual monetary policy rules.

According to staff papers of IMF (2005, 2008), the impact of external shocks on the Ukrainian economy largely depends on exchange rate regime adopted by the NBU. In most cases, greater exchange rate flexibility can help absorb the shock and contribute to the protection of the economy from downside risks and at the same time allow it to profit from upside risks. As exchange rate depreciation is an important source of inflation dynamics, we agree with conclusions of Kopych (2015). He suggests fiscal discipline in Ukraine as a stabilisation policy tool to control the budget deficit, which is a factor behind the exchange rate depreciation.

[9] Variance decomposition results are available upon request.

5 Conclusion

In this paper, we assess the importance of foreign shocks for macroeconomic variance in Ukraine over the period from February 2003 till December 2016 by estimating a small-scale structural VAR model with block exogeneity restriction. The main goal was to contribute to autoregressive analysis of the Ukrainian economy and extend the existing studies by the inclusion of a broader range of external shocks, in particular from the EU (eurozone) and Russia, main trade partners of Ukraine. First, we wanted to estimate how important are external shocks for aggregate fluctuations in Ukraine in general; second, to investigate whether Ukrainian economic environment is significantly influenced by Russian monetary policy; third, to assess whether euro area interest rate shocks account for a sizable fraction of macroeconomic variation in Ukraine.

We find that a significant share of the macroeconomic variation in Ukraine can be attributed to external shocks. In particular, external shocks account for up to 97 % of volatility in Ukraine's output and 85 % in inflation. Among external shocks, output shock originating in the EU has the strongest effect on real output in Ukraine and accounts for 84-90 % in the variance with the strongest effect in the long run. The most prominent effect on inflation in Ukraine in the short run (3 months) has inflationary shock from Russia (about 10 %), while in the middle and long run the most influential is output shock from the EU (60-75%) with the strongest impact in the long run. Output shock from the EU also has the biggest effect on the nominal UAH/EUR exchange rate in Ukraine and accounts for 40-68 % in its variance, while for the nominal interest rate in Ukraine the most influential is inflationary shock from the EU, which accounts for 44-77 % with its strongest impact in the short run. Remarkably, foreign monetary policy shocks (both from the EU and Russia) account for about 1 % of the variance in real output and the price level in Ukraine, even though the effect is significant according to impulse responses. Our findings are in line with the results of other studies (Cushman & Zha 1997, Giordani 2004, Horvath & Rusnák 2008, Erten 2012), as they also find that a significant share of the variance in output and inflation in the analysed countries originates from external shocks. Finally, we conclude that the inclusion of Russia in the model is important to achieve correct model specification and avoid an overstatement of the impact of shocks originating from the EU on the Ukrainian economy.

The results of the analysis have implications for both theoretical modelling and policy in Ukraine. According to our findings, theoretical models of the Ukrainian economy should account for external shocks. Theorists and modellers also have to decide about which transmission mechanism for external shocks to pay attention to in their models. Our results suggest that international trade is important in the transmission mechanism for external shocks in Ukraine, while foreign interest rates are of minor importance. In light of the adoption of the IT regime by Ukraine starting from 2017, our results suggest that the National Bank of Ukraine should closely track external developments to achieve inflation targets. A flexible exchange rate, inflation targeting and counter-cyclical fiscal policy would help to limit the effects of fluctuations in the economy.

At the same time, our model and the results could be further improved in the following two directions. First, the relations between Ukraine, Russia and the EU have changed dramatically after 2014, which may be considered as a structural shock and treated accordingly. Therefore, it is reasonable to replicate this analysis analysis again over the period starting from 2014, after we can construct a consistent data set for a reasonable period of time (or use Bayesian techniques), in order to see how this change affected macro volatility and transmission of shocks in Ukraine. Second, one might include some other country, which also influences Ukraine's economy. Given a high level of dollarisation of the Ukrainian economy, it could be the US. This would have important implications for domestic policy responses to international shocks. Without the effects from this country, domestic monetary policy will over-react to a Russia/EU based shock.

Even though from our results the effectiveness of domestic monetary policy in Ukraine seems to be largely constrained, it does not imply that domestic policy is generally unimportant in Ukraine. From SVAR estimates we see that domestic policy shocks still account for a significant share of the macroeconomic variation in Ukraine, especially in inflation in the short run. Analysis of domestic policy shocks and their effects on the Ukrainian economy could be considered as an important question for future research. Moreover, there is no study yet that would investigate the systematic reaction of domestic policy in Ukraine to external shocks and how it affects macroeconomic dynamics in Ukraine. Therefore, investigation of the systematic reaction of domestic policy in Ukraine to external shocks can be considered as another important question for future research.

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Appendix A: Stylized facts about Ukraine

Trade openness (exports plus imports as percent of GDP, in 2016): Ukraine 105% — compared with Denmark 99% and Austria 101% (The World Bank, 2016a).

The main export destinations of Ukraine, in 2016: 37.2% to the EU (28), 9.9% to Russia (European Commission, 2017). Two biggest categories of Ukraine's exports in 2015 were manufactures (48.9%), such as iron's semi-finished products and iron ores, and agricultural products (40.4%), such as sunflower-seed oil and maize (WTO, 2016). The largest EU importers of goods from Ukraine in 2016 were Italy (15%) and Poland (14%), followed by Germany (11%), Hungary and Spain (around 8% each) (Eurostat, 2017).

Origins of imports of Ukraine, in 2016: 43.7% from the EU, 13.1% from Russia (European Commission, 2017). Two biggest categories of Ukraine's imports in 2015 were petroleum gas (12.4%) and refined petroleum (10%) (WTO, 2016). The largest exporters of goods to Ukraine in 2016 among the EU Member States were Germany (22% of EU exports of goods to Ukraine) and Poland (21%), followed by Hungary (9%) and Italy (7%) (Eurostat, 2017).

Sixteen European countries showed a surplus in trade with Ukraine in 2016: Germany and Poland. In contrast, the largest deficits were recorded in Italy and Spain (Eurostat, 2017).

GDP of Ukraine (at current prices and exchange rates in 2016) equals 7.27% of Russia's GDP and 0.78% of the EU's GDP (World Bank data, 2016b).

Appendix B: Data

Table 9: Data Sources

Variable	Abb.	Definition	Source
Commodity prices	CP	All Commodity Price Index, 2005 = 100, includes both Fuel and Non-Fuel Price Indices, in terms of U.S. dollars	IMF, index: PALLFNF
EU (19)			
Output	GDP_{EU}	Quarterly real GDP	Eurostat
Inflation	INF_{EU}	Consumer Price Index	Eurostat
Interest rate	I_{EU}	Short-term interest rates, % per annum	OECD (2017), doi: 10.1787/2cc37d77-en
Russia			
Output	GDP_{RUS}	Quarterly real GDP	Rosstat
Inflation	INF_{RUS}	Consumer Price Index	Rosstat
Interest rate	I_{RUS}	Short-term interest rates, % per annum	OECD (2017), doi: 10.1787/2cc37d77-en
Ukraine			
Output	GDP_{UA}	Quarterly real GDP	Ukrstat
Inflation	INF_{UA}	Consumer Price Index	Ukrstat
Interest rate	I_{UA}	Interest rates of banks' refinancing by the NBU, average weighted rate on all instruments, %	NBU
Exchange rate	E_{UA}	UAH for 100 EUR, monthly average	NBU

Note: The table presents a summary of the key variables of the SVAR model, their abbreviations, corresponding indicators and a way of measure, as well as their sources and codes. Accessed on 26 November 2017.

Appendix C: Results of the estimation

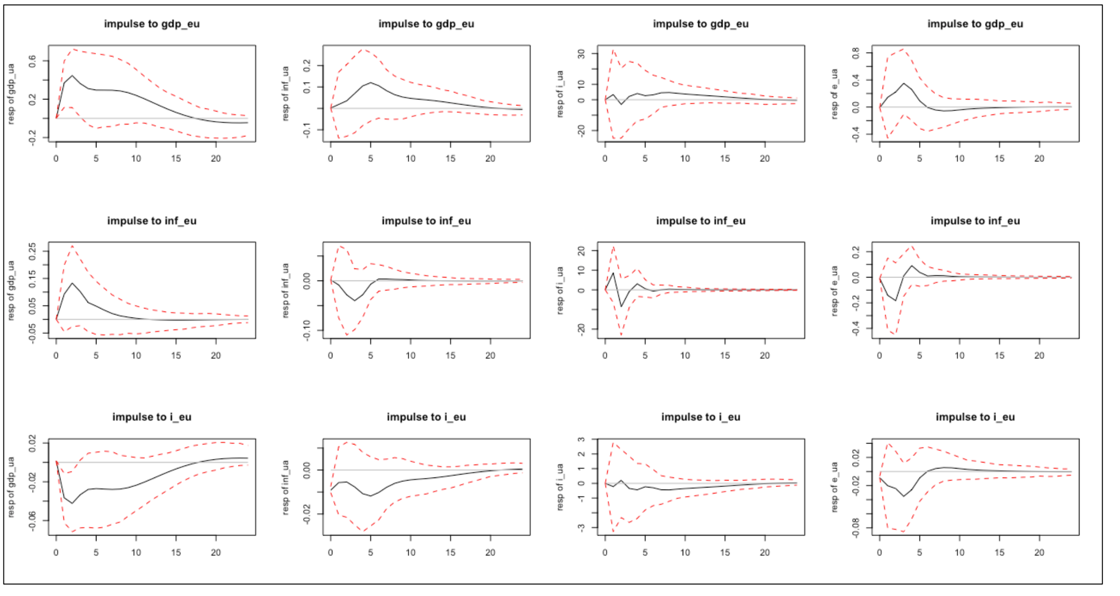
Table 10: Misspecification tests of the restricted VAR

Test	df	Results
Roots		0.8858790; 0.8858790; 0.6896461; 0.6896461; 0.6068232; 0.6068232; 0.5681182; 0.5681182; 0.5050542; 0.5050542; 0.4523161; 0.4272606; 0.4272606; 0.4192094; 0.4020472; 0.4020472; 0.3618037; 0.2928313; 0.2928313; 0.1633652; 0.1633652; 0.1548527
Portmanteau Test	1694	1835.4 [0.008752]
Jarque-Bera (J-B) Test	22	5352.8 [< 2.2e-16]
ARCH-LM tests per equation	16	cp: 14.625 [0.5523]
	16	gdp_eu: 52.207 [1.014e-05]
	16	inf_eu: 10.992 [0.81]
	16	i_eu: 8.4004 [0.936]
	16	gdp_rus: 26.905 [0.04255]
	16	inf_rus: 7.9774 [0.9495]
	16	i_rus: 40.593 [0.0006375]
	16	gdp_ua: 7.1704 [0.9698]
	16	inf_ua: 26.449 [0.04802]
	16	i_ua: 33.531 [0.00628]
	16	e_ua: 33.267 [0.006811]

Source: author's calculations.

Note: The table presents the results of the following misspecification tests of the restricted VAR model: roots (the eigenvalues of the companion coefficient matrix), Portmanteau test for serial correlation in residuals, J-B test for normality of residuals, ARCH-LM test per each equation. p-values are reported in brackets, df – degrees of freedom. If the modulus of the root closest to the unit circle boundary was higher than 1, it would indicate that VAR is not stationary. The rejection of the null hypotheses of the Portmanteau test indicates that there is no serial correlation left in residuals. The rejection of the null hypothesis of the J-B test indicates different kurtosis of residuals than normal.

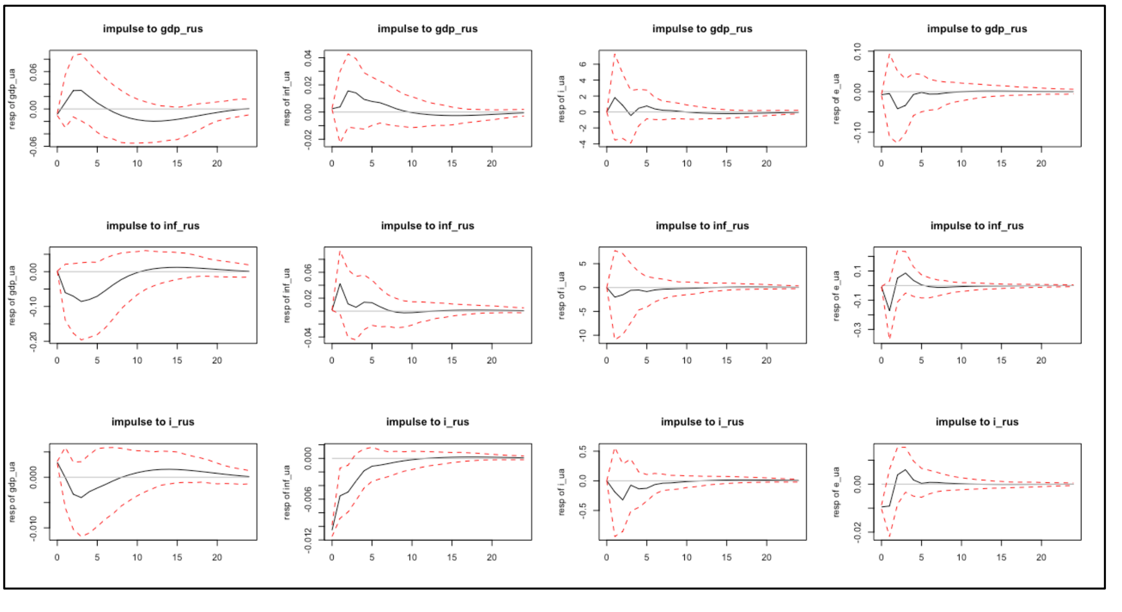
Figure 11: Responses of Ukrainian variables to shocks from the EU



Source: Author's calculations.

Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to shocks from the EU (GDP, inflation, interest rate). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

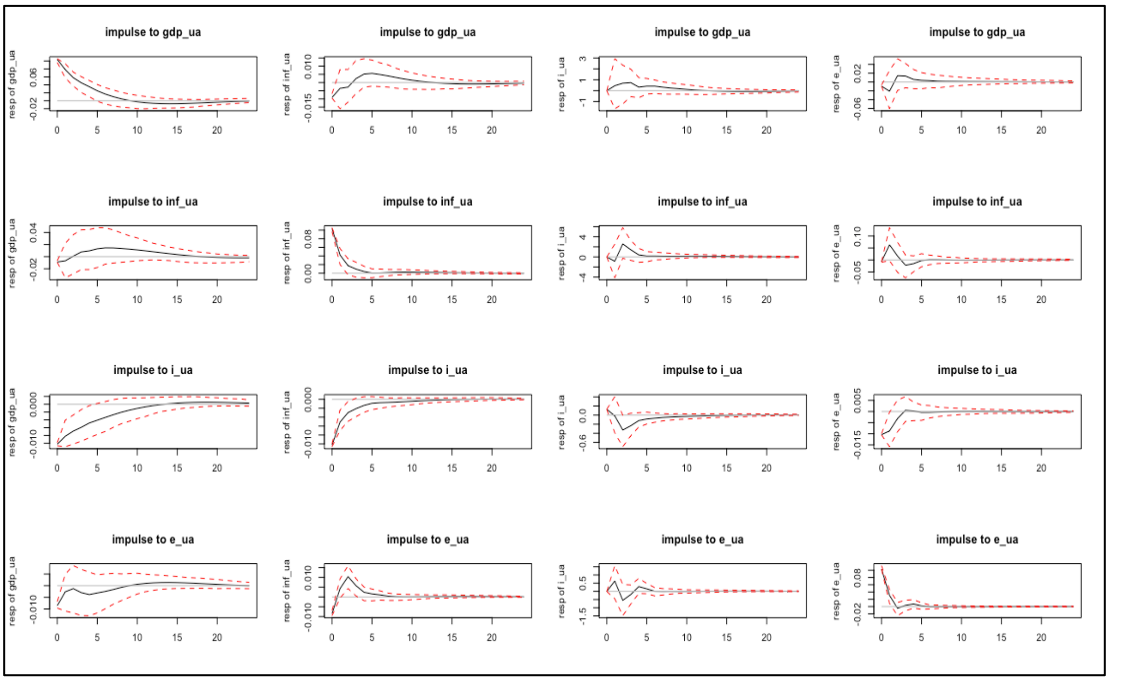
Figure 12: Responses of Ukrainian variables to shocks from Russia



Source: Author's calculations.

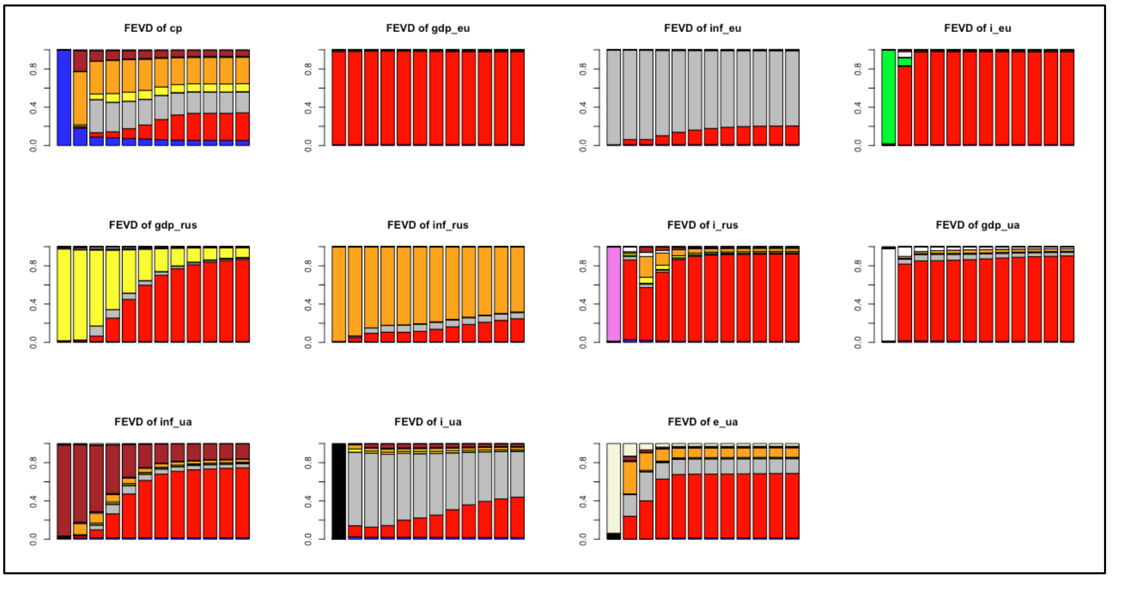
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to shocks from Russia (GDP, inflation, interest rate). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 13: Responses of Ukrainian variables to shocks from Ukraine



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to shocks from Ukraine (GDP, inflation, interest and UAH/EUR exchange rates). The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 14: Variance decomposition (FEVD)

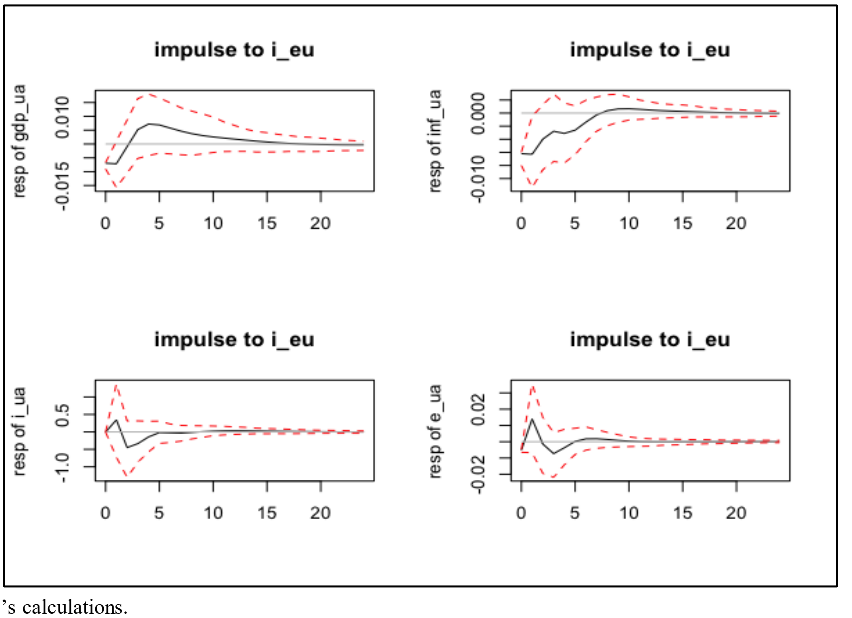


Source: Author's calculations.
Note: The figure presents forecast error variance decomposition of all variables. The first row (from left): commodity prices, EU's output, EU's inflation, EU's interest rate. The second row (from left): Russia's output, Russia's inflation, Russia's interest rate, Ukraine's output. The third row (from left): Ukraine's inflation, Ukraine's interest rate, UAH/EUR exchange rate.

Appendix D: Sensitivity Analysis

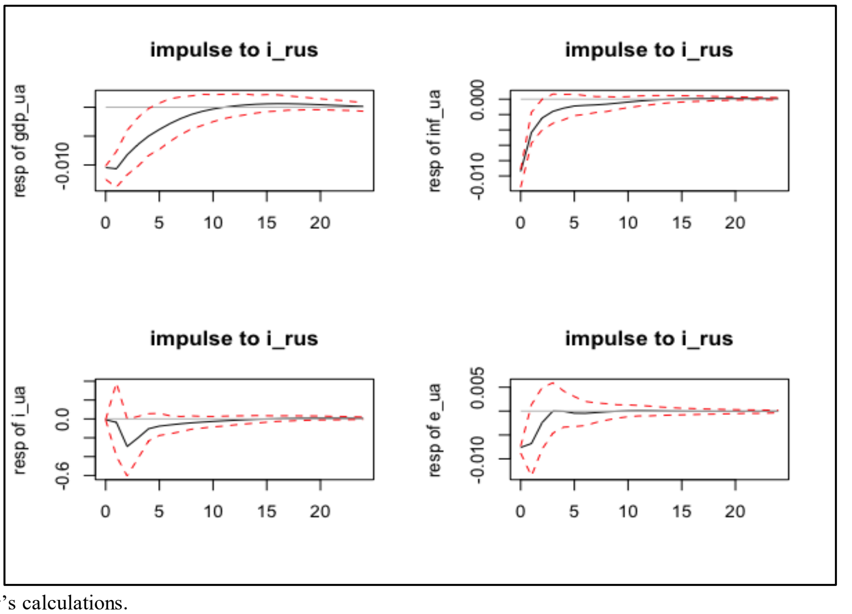
Different identification scheme – Choleski recursive scheme

Figure 15: Responses of Ukrainian variables to monetary shock from the EU (Choleski)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from the EU. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

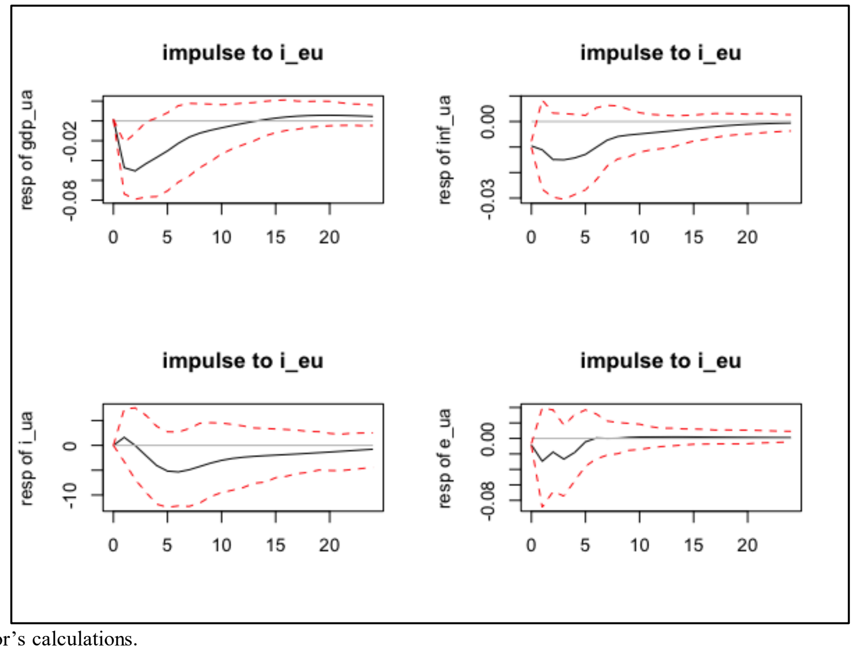
Figure 16: Responses of Ukrainian variables to monetary shock from Russia (Choleski)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from Russia. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Interest rates in levels

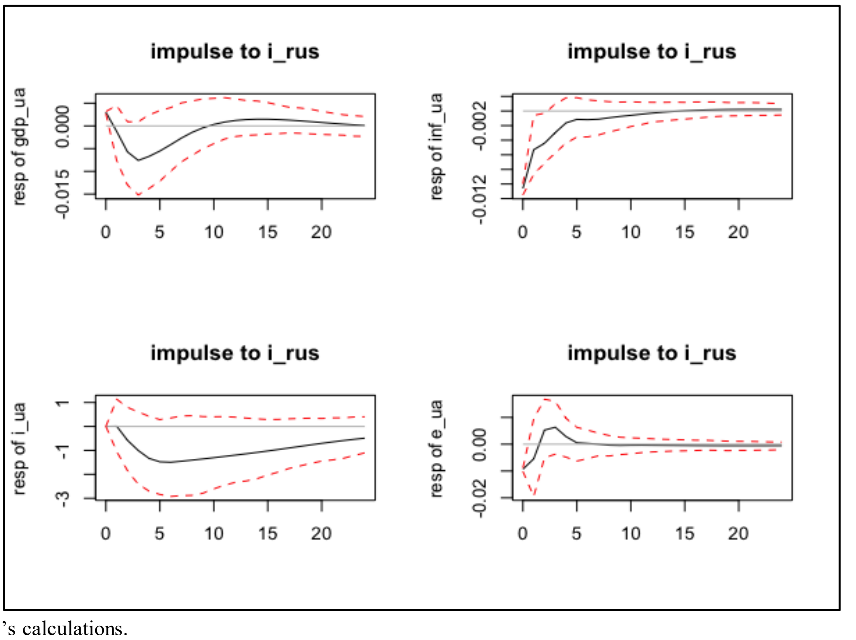
Figure 17: Responses of Ukrainian variables to monetary shock from the EU (interest rates in levels)



Source: Author's calculations.

Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from the EU. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 18: Responses of Ukrainian variables to monetary shock from Russia (interest rates in levels)

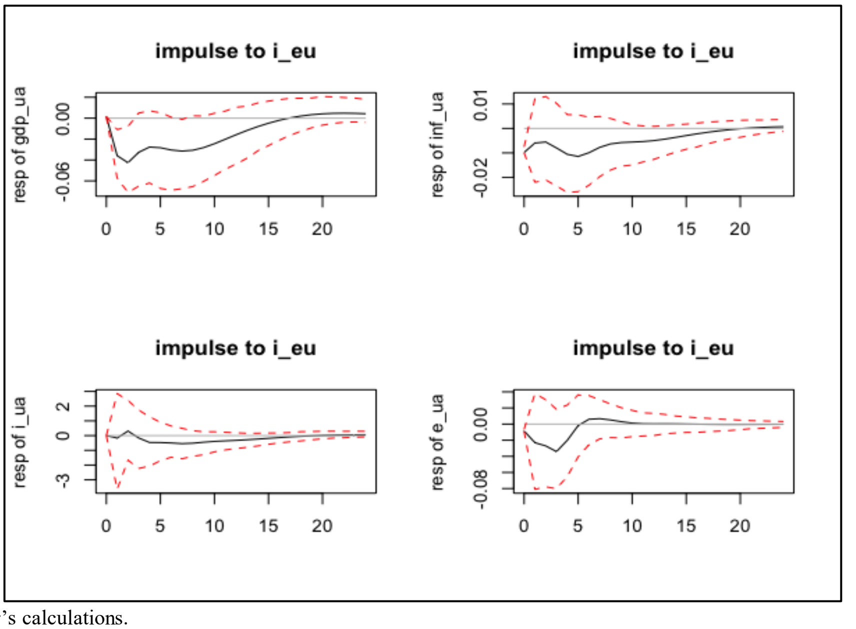


Source: Author's calculations.

Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from Russia. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

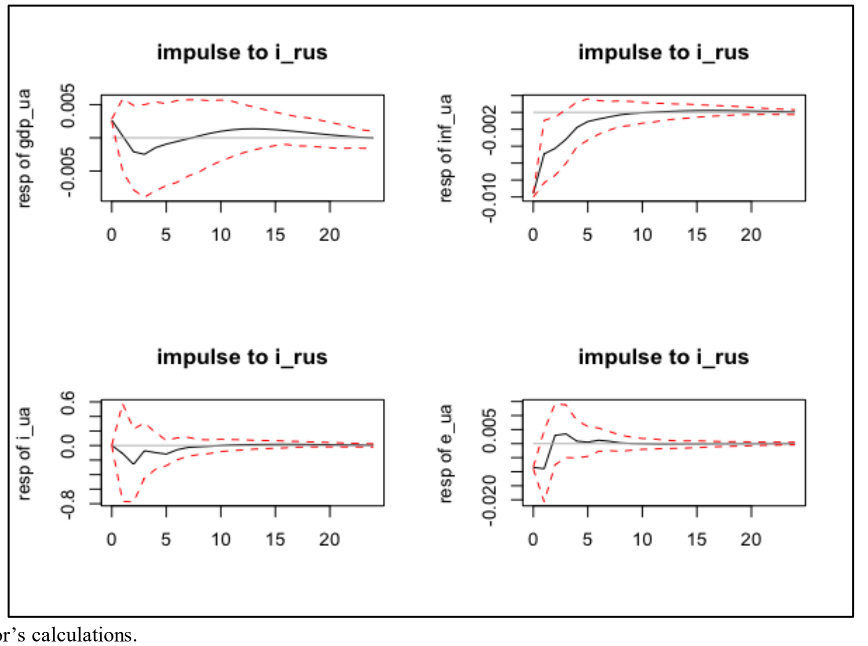
Oil price index

Figure 19: Responses of Ukrainian variables to monetary shock from the EU (oil price index)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from the EU. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

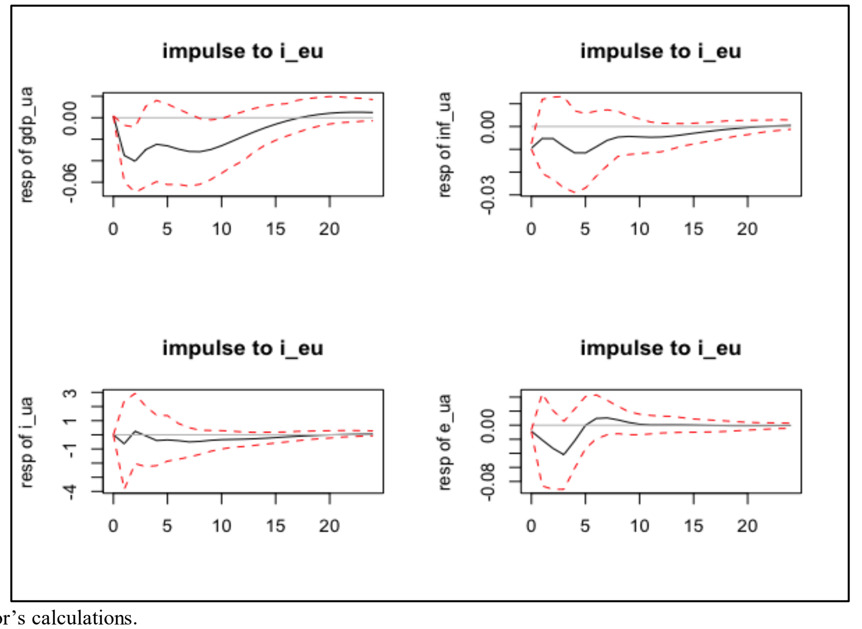
Figure 20: Responses of Ukrainian variables to monetary shock from Russia (oil price index)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from Russia. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

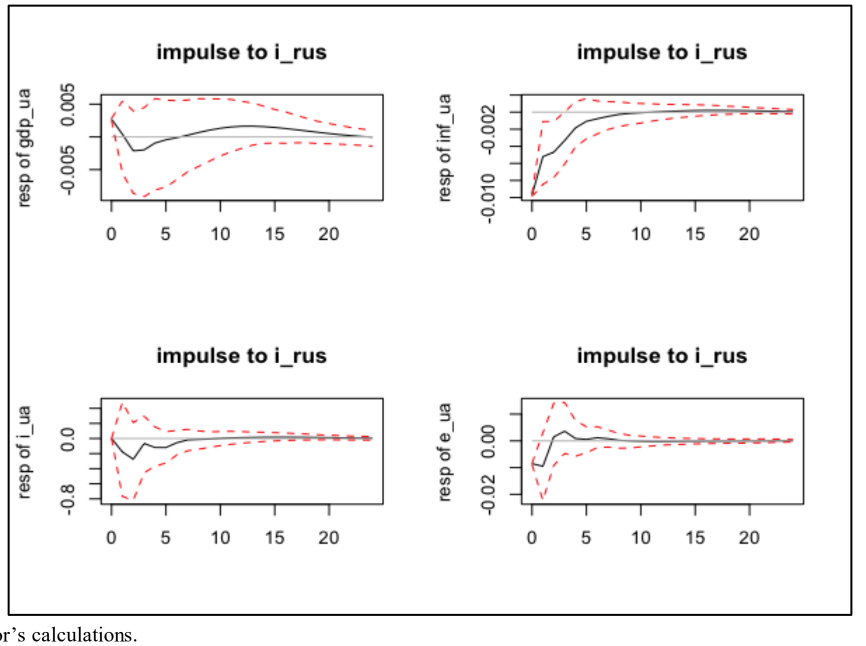
Metals price index

Figure 21: Responses of Ukrainian variables to monetary shock from the EU (metals price index)



Source: Author’s calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from the EU. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

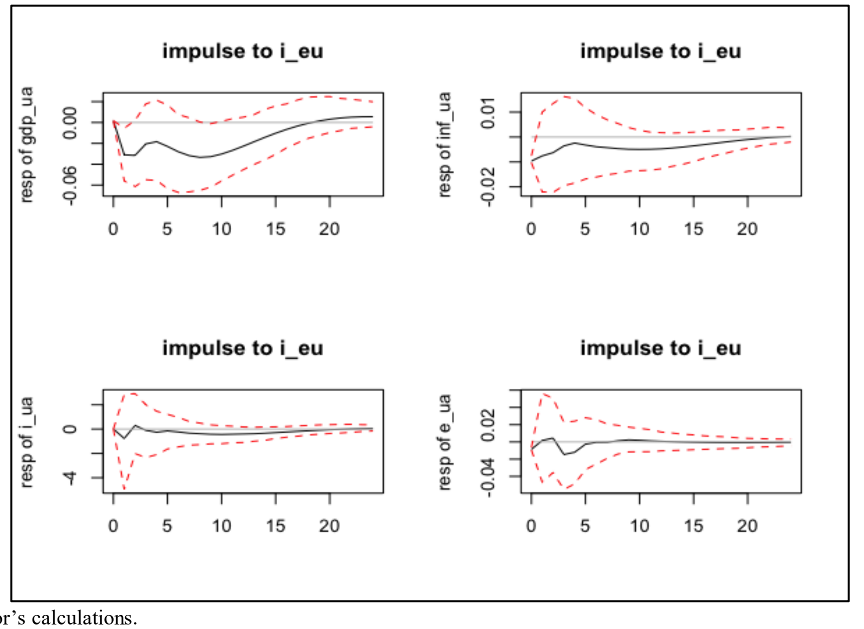
Figure 22: Responses of Ukrainian variables to monetary shock from Russia (metals price index)



Source: Author’s calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from Russia. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

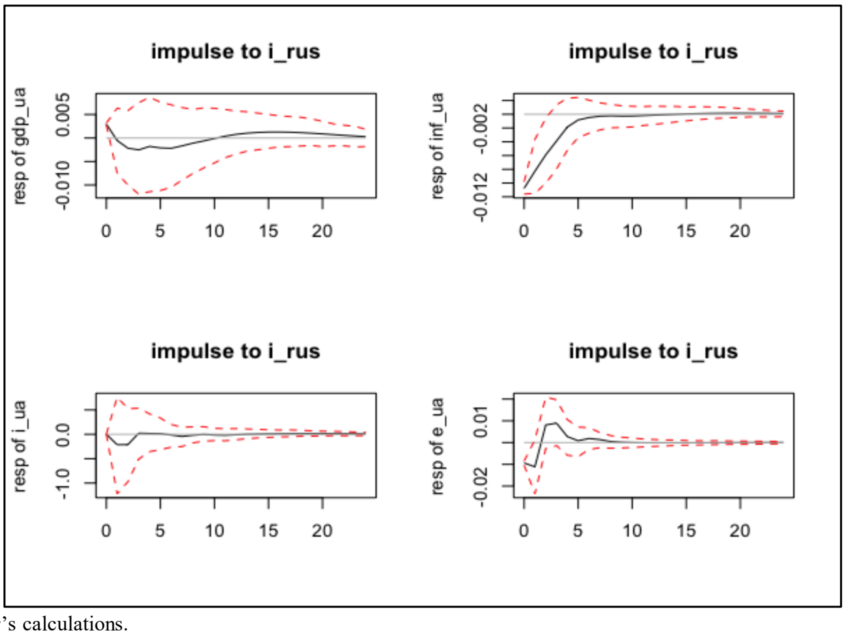
Shorter data set, till December 2013

Figure 23: Responses of Ukrainian variables to monetary shock from the EU (shorter data set)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from the EU. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.

Figure 24: Responses of Ukrainian variables to monetary shock from Russia (shorter data set)



Source: Author's calculations.
Note: The figure presents impulse responses of Ukrainian variables (GDP, inflation, interest and UAH/EUR exchange rates) to a positive monetary shock from Russia. The impulse responses are obtained from a one standard deviation shock and are plotted with 95% confidence bands (dashed lines), which were bootstrapped using 500 replications.