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Propagation of economic shocks from Russia and Western European countries to CEE-Baltic countries: a comparative analysis

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Abstract

What is the relative importance of Russia and Western European countries on Central and East European and Baltic (CEE-Baltic) countries? This paper tries to address this geo-politically important question by quantifying and comparing the spillover effects of a growth and trade shocks coming out of Russia and three major Western European countries (i.e. Germany, France and Italy) on ten CEE-Baltic countries. It uses a global vector autoregression (GVAR) model with quarterly data from 2003Q1-2015Q3. In constructing the foreign variables, a time varying trade weight is used instead of a fixed weight in order to take account of the financial crisis of 2007-08 and the recent economic sanctions on Russia. The results show that growth spillover effects are strong in the region. However, shocks to Russia have higher and persistent spillover effects on CEE-Baltic countries compared to shocks to Western European countries. Spillover effects of growth shocks also show that Russia is affected more by Western European countries than the other way round. Trade balance shocks on the other hand do not play an important role in this transmission process.

Keywords: economic growth, spillover effects, global vector autoregression, Central and East European countries

JEL classification: C32, F43, O47

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1 Introduction

The Central and Eastern European and Baltic (CEE-Baltic from now on) countries, situated between Western European countries in the west and Russia in the east, had a mixed economic relation with both sides over the years. After the fall of the Berlin Wall, many of these former Soviet states faced an incomplete process of integration without a clear economic and foreign policy attachment. As they started transforming their economies from what has been known as central planning economy to market oriented economy, integration with the euro area started to increase. Comparatively well developed and matured markets in Western European countries and rapid economic catching up of these transition economies resulted in high Western FDI inflows [1]. Geographical proximity, improved business environment and several agreements lead to reduced barriers to labor mobility and helped to reduce trade barriers significantly. In the last two decades, almost all of these countries became members of the European Union (EU) and North Atlantic Treaty Organization (NATO). Slovakia, Slovenia, Estonia, Latvia and Lithuania even adopted the Euro as their single currency. As a result, both trade links and financial ties intensified between these two groups of countries. Though these links helped the CEE-Baltic states to grow, they also became more vulnerable to external negative shocks. This was evident from the recent global financial crisis and the ensuing sovereign debt crisis in the euro area.

Surprisingly, on the other side, there was very little negative impact on the volumes of foreign trade turnover between Russia and CEE-Baltic states in spite of the adoption of the EU trade regime. In fact, in the last decade prior to the economic sanctions on Russia, there has been a remarkable increase in economic exchange between Russia and CEE-Baltic countries, with trade increasing several fold. After the incidents involving Crimea in 2014 and the successive sanctions on Russia, the economic interaction between Russia, CEE-Baltic and other Western European countries started to gain attention in geo-political discussions.

[1] See Hlavacek and Bal-Domanska (2016)

The recent election in the USA and tensions involving Syria raised new debates regarding how sanctions on Russia should be handled. The possibility of such sanctions affecting the NATO and EU members in the west is also discussed heavily in economic and political circles. Therefore, it is increasingly important to understand how these countries are interconnected and how a shock in one region can spill over to other regions.

Though there is a growing literature on the spillover effects within the major EU countries and between developed and emerging economies, studies focusing on CEE-Baltic countries remain limited mostly due to lack of sufficiently long macroeconomic time series data. With the increase in data availability, they now deserve more analysis. The few studies that analyze the spillover effects from Western European countries to Eastern European countries mostly concentrate on the effects through the capital and financial markets (i.e. Syllignakis and Kouretas (2011), Serwa and Bohl (2005), Backe and Slacik (2013), Harrison and Moore (2009) etc.). Some papers discuss the effects of ECB monetary policy on non-eurozone members of the EU (i.e. Benkovskis et al. (2011), Horvath and Rusnak (2009), Kucharcuková et al. (2016) etc.). Focus on other variables has been scarce. Among them, Jimenez-Rodriguez et al. (2010) uses a near VAR model with macroeconomic data consisting of interest rates, industrial production and commodity prices for the euro area, the USA and ten CEE countries. The results show a positive shock in foreign economies like the USA and euro area results in a reduction in industrial production and prices in CEE countries. Hájek and Horváth (2016) study similar variables and find that the response of CEE countries to euro area shocks is almost as strong as the response of the euro area countries itself. Maćkowiak (2006) investigates the sources of the variation in real aggregate output and aggregate price level in the Czech Republic, Hungary and Poland. He finds German macroeconomic variables have significant effects on domestic variables of these countries. Keppel and Prettner (2015) employ a generalized impulse response analysis to investigate the interrelations between the Euro area and five CEE countries (i.e. Czech Republic, Hungary, Poland, Slovenia and Slovakia). The results show that a positive shock in euro area

GDP has a positive effect on the GDP of CEE countries. Feldkircher (2015) builds a global macroeconomic model for 43 countries including the CEE countries and mainly checks the effects of output, interest rate and oil price shocks. It shows that the CEE output reacts nearly equally strongly to an U.S. output shock as it does to a corresponding euro area shock.

This paper uses a global vector autoregressive (GVAR) method to investigate the impact of economic growth and trade balance of Russia and the three largest Western European countries on CEE-Baltic countries using the quarterly data for the period of 2003Q1-2015Q3. It contributes to this literature in three ways. Firstly, it focuses on the spillover effects from Russia to CEE-Baltic countries separately in addition to the effects from Western European countries. As a result it is possible to compare the relative effects. Previous literature mostly focused on the effects from Western European countries. It is very surprising given the relative size of the Russian economy compared to other CEE-Baltic countries, its geographic proximity and influence. Also, rather than concentrating on capital and financial markets, this paper focuses on growth, trade, exchange rates and capital flows as the domestic variables as they are more likely to get affected due to a sanction or foreign shock. Secondly, it uses global vector auregression (GVAR) analysis, a novel econometric approach proposed by Pesaran et al. (2004). Compared to factor augmented VAR (FAVAR) models, which are also used in multi country spillover analysis, the GVAR approach can combine different macroeconomic variables of a large number of countries in a very convenient manner. Here, individual country models are added through a consistent econometric approach to get a global model where cointigration is allowed for variables within and across countries. On the other hand, FAVAR models capture country-specific dynamics only through the idiosyncratic components (i.e.the residuals). Also, in FAVAR models variables are often made stationary via differencing. In GVAR models, data can be used in levels and thus the long run information in the data is retained. Though two previous papers, Hájek and Horváth (2016) and Feldkircher (2015), used GVAR models for CEE countries, the former concentrated on a different set of variables excluding Russia and the latter did not study the effects of a shock in the Russian economy on CEE-Baltic countries. Thirdly, this paper considers an extended sample period which includes the financial crisis and the economic sanctions on Russia.

The results will help to create a better picture of the relative importance of Russia and Western European countries on CEE-Baltic countries. This in turn can have important implications on economic and political decision making for all the countries in the region. This paper is organized as follows: section 2 describes the GVAR model, section 3 explains the data, some important statistical properties of the GVAR model and some initial results, section 4 discusses the results of impulse response analysis and section 5 concludes.

2 The GVAR model

The GVAR approach introduced by Pesaran et al. (2004) gives a relatively simple yet effective way to model today's global economy where each country and different macroeconomic factors within countries are related with each other. The methodology of GVAR modelling consists of two different stages. First of all, a separate VARX model is estimated for each country separately. If some of the variables have unit roots and they are cointegrated, the model is estimated in their error correcting form. In these individual VARX (or VECMX) models, each country has two different types of variables: domestic and foreign. Domestic variables are endogenous in the model while the foreign variables are exogenous. Each domestic variables have its corresponding foreign variables. These foreign variables are constructed using a weight matrix so that the relative importance of different countries are reflected properly. They provide a connection between the evolution of the domestic economy and rest of the world. These foreign variables need to be weakly exogenous, an assumption that needs to be tested. In the second step, these individual VARX (or VECMX) models are combined together in a consistent manner with the help of a link matrix to build a global model.

- **Individual country model**

Let there be $N + 1$ countries in the model, indexed by $i = 0, 1, 2, \ldots..N$, where country 0 is considered the reference country. Each country i then follows the $VARX(p, q)$ model:

$$y_{i,t} = a_{i,0} + a_{i,1}t + \sum_{j=1}^{p} \alpha_{i,j} y_{i,t-j} + \sum_{j=1}^{q} \beta_{i,j} y^*_{i,t-j} + u_{i,t} \tag{1}$$

for $t = 1, 2, ..., T$. Here, $k_i \times 1$ matrix $y_{i,t}$ represents the endogenous domestic variables and $k_i^* \times 1$ matrix $y^*_{i,t}$ represents the corresponding (weakly)exogenous foreign variables. k and k^* are the numbers of domestic and foreign variables respectively (here $k = k^*$), $a_{i,0}$ is a $k_i^* \times 1$ vector of fixed intercepts and $a_{i,1}$ is a $k_i^* \times 1$ vector of coefficients on the deterministic time trends. p and q are the lag lengths of the domestic and foreign variables respectively. They are selected according to the Schwartz Baysian (SB) criterion. Finally, $u_{i,t}$~iid $(0, \sum u_i)$.

Foreign variables are calculated as the weighted average of the rest of the countries value of that variable. More specifically,

$$y^*_{i,t} = \sum_{j=0}^{N} w_{i,j} y_{j,t} \tag{2}$$

where $w_{i,j}$ for $i, j = 0, 1, \ldots, N$ are the set of weights (usually computed from the trades between the countries) that captures the importance of country j for country i. The weights satisfy the following condition : $\sum_{j=0}^{N} w_{i,j} = 1$ for $i, j = 0, 1, 2 \ldots, N$ and $w_{i,i} = 0$ for $i = 0, 1, ...; N$. Most of the GVAR literature uses fixed trade weights based on bilateral trade volumes. However, these may be subject to temporal changes, particularly for the time period considered in this paper as it contains the periods of financial crisis of 2007-08 and the recent economic sanctions on Russia. As a result using a fixed weight might mislead the results. In order to take account of these changes that took place throughout the sample period, this paper uses time-varying weights to construct the foreign variables in the country-specific models. These are constructed as three-year moving averages to smooth out short-run business-cycle effects in the bilateral trade flows. More compactly, setting $p_i = max(p, q)$, equation 1 can be written as:

$$A_{i,0} z_{i,t} = a_{i,0} + a_{i,1} t + \sum_{j=1}^{p_i} A_{i,j} z_{i,t-j} + u_{i,t} \tag{3}$$

where vector $z_{i,t} = ({x_{i,t}}', {x^*_{i,t}}')'$ represents both domestic and foreign variables and coefficient matrices are $A_{i,0} = (I_{k,i}, -\beta_{i,0})$ and $A_{i,j} = (\alpha_{i,j}, \beta_{i,j})$.

Because of the characteristics of the macroeconomic variables and to allow for the cointegrating relationship within and between countries, the country specific VARX models are estimated in the following error correction form (VECMX):

$$\Delta y_{i,t} = c_{i,0} - \alpha_i \beta_i' (z_{i,t-1} - a_{1,t}(t-1)) + \beta_{i,0} \Delta y^*_{i,t} + \sum_{j=1}^{p_i - 1} \phi_{i,j} \Delta z_{i,t-j} + u_{i,t} \tag{4}$$

Here, α_i is a $k_i \times r_i$ matrix of rank r_i and β_i is a $(k_i + k^*_i) \times r_i$ matrix of rank r_i. The country specific VECMX models are estimated using reduced rank regression conditional on the weakly exogenous foreign variables. This takes into account the possibility of cointegration within domestic variables and across domestic and foreign variables. This way estimates for r_i, β_i and α_i are obtained. The other parameters are estimated by OLS from this equation:

$$\Delta y_{i,t} = c_{i,0} + \delta ECM_{i,t-1} + \beta_{i,0} \Delta y^*_{i,t} + \phi_i \Delta z_{i,t-1} + u_{i,t} \tag{5}$$

where $ECM_{i,t-1}$ are the error correction term referring to the r_i cointegrating relations of the ith country model.

•The global model

The next step is to combine the individual country specific parameter estimates into a single global model. All country specific variables are considered as a single $k \times 1$ global vector $y_t = (y'_{0t}, y'_{01}, ..., y'_{Nt})'$ where $k = \sum_{i=0}^{N} k_i$, so that all the variables are endogenous in the system as a whole. For each country, the corresponding VARX model is obtained from the VECMX model that was estimated. The link matrix W_i, which is the $(k_i + k^*_i) \times k$ matrix collecting the trade weights w_{ij}, $\forall i, j = 0, 1, 2, ..., N$ is used to obtain the identity $z_{i,t} = W_i y_t$.

From equation (3), it follows that:

$$A_{i,0}W_i y_t = a_{i,0} + a_{i,1}t + \sum_{j=1}^{p_i} A_{i,j}W_i y_{t-j} + u_{i,t} \tag{6}$$

for $i = 0, 1, ..., N$. Then the $N+1$ systems in (6) are combined to get the global model in levels:

$$G_0 y_t = a_0 + a_1 t + \sum_{i=1}^{p} G_i y_{t-i} + u_t \tag{7}$$

Here, $G_0 = (A_{00}W_0, A_{10}W_1, ..., A_{N0}W_N)'$ is a known non singular $k \times k$ matrix that depends on the trade weights and parameter estimates $G_i = (A_{0i}W_0, A_{1i}W_0, ..., A_{Ni}W_N)'$ for $i = 1, 2, .., p$, $a_0 = (a_{00}, a_{10}, ..., a_{N0})'$, $a_1 = (a_{01}, a_{11}, ..., a_{N1})'$, $u_t = (u_{0t}, u_{1t}, ..., u_{Nt})$ and $p = max(p_i)$ across all i. Premultiplying (7) by G_0^{-1}, the GVAR (p) model is obtained as

$$y_t = b_0 + b_1 t + \sum_{i=1}^{p} F_i y_{t-i} + \varepsilon_t \tag{8}$$

Where, $b_0 = G_0^{-1}a_0$, $b_1 = G_0^{-1}a_1$, $F_i = G_0^{-1}G_i$ for $i = 1, 2, ..., p$ and $\varepsilon_t = G_0^{-1}u_t$. The dynamic properties of the GVAR model in (8) can be examined using Generalized Impulse Response Functions (GIRFs).

3 Data and relevant tests

This section describes the data, some test results that are important for the GVAR model to hold and the contemporaneous effects which gives initial information about the level of integration of different countries.

3.1 Data

The GVAR model consists of 14 countries. In addition to Russia and three of the largest Western European countries in terms of GDP (Germany, France and Italy), the model also includes ten CEE-Baltic countries (Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Estonia and Latvia). Other smaller CEE-Baltic countries were left out mainly due to unavailability of data for longer periods. In addition to GDP growth (GROWTH), three other variables are used in each country model: trade balance (TB), capital flows (CF) and real effective exchange rate (REER)[2]. Theoretically these variables can play a role in the transmission mechanism of growth and can be vulnerable to foreign shocks. Quarterly data from 2003:Q1 to 2015:Q3 is used. Trade balance is the difference between the values of exports and imports. Since most of the countries in the sample have their own currencies, measuring and using the data for trade balance and capital flows in different currencies can lead to misleading results. Therefore, to make comparison easier, data for these variables are taken from Oxford Economics which converts them into a common currency (US dollar). Real effective exchange rate data were taken from IMF's IFS data set and it is the average of bilateral real exchange rates between the country's currency and other major currencies. This helps to mitigate the volatility in the exchange rate due to any sudden change in bilateral relations among countries. If the data were not available in seasonally adjusted form, they were adjusted using the census X-12 method. The three Western European countries are considered together as a region (named as 'West' from now on). All the four variables of this region are constructed in the following way from individual country data:

$$y_t = \sum_{l=1}^{N_i} W_l y_{l,t}$$

where y_t is the regional variable, $y_{l,t}$ is the value of that variable for country l and W_l is represents the relative importance of country l. Following Dees et al. (2007), W_l is computed for each country by dividing the latest PPP-GDP value of each country by the total sum across countries, such that the weights add up to one across the countries.

[2]except Estonia, Latvia and Slovenia for which capital flows data were unavailable

3.2 Statistical properties and specifications of VARX model

I start by checking the stationarity and co-integration of the data. Firstly, stationarity is checked for all the country specific domestic variables and their corresponding foreign variables. In addition to the commonly used Augmented Dickey Fuller (ADF) test, the Weighted-Symmetric Dickey Fuller (WS) test suggested by Park and Fuller (1995) is also used for this purpose[3]. Lag length was selected according to the Schwartz Baysian (SB) criterion. Unit root tests are conducted with variables in levels, first differences and second differences (if necessary). When the variables are in levels an intercept and time trend is included whereas when in first or second differences only an intercept is included. The results for the level data for domestic variables are shown in table (1). The numbers express the t-values at 5% significance. As expected, there is a mix of stationary and non-stationary data across countries while most of the data fall in the latter category. All the nonstationary data are integrated of order one.

The next step is to define the country specific VARX models. The GVAR model has the flexibility of handling different specifications for different countries (i.e. the number of domestic and foreign variables goes into each country specific model). However, since the countries in the sample have trading relations and are expected to affect each other, all individual country models initially include all four variables as domestic and foreign variables [4] (constructed using the weight matrix mentioned in the previous section). Next, the order of the country specific VARX (p_i, q_i) model is selected using the Schwarz Bayesian (SB) criterion. While selecting the lag order, p_i and q_i were not allowed to go over 2 because of

[3]The WS test exploits the time reversibility of stationary autoregressive process in order to increase their power performance. Many authors like Leybourne et al. (2005) and Pantula et al. (1994) showed evidence of superior performance of WS test compared to ADF test.

[4]Several robustness checks were also conducted by leaving out some variables as foreign variables for some countries which are less integrated with other countries in terms of trade. However the main findings of the paper do not change.

Table 1: Unit root tests

Domestic Variables	GROWTH	GROWTH	TB	TB	CF	CF	REER	REER
Statistic	ADF	WS	ADF	WS	ADF	WS	ADF	WS
Critical Value	-3.45	-3.24	-3.45	-3.24	-3.45	-3.24	-3.45	-3.24
Bulgaria	-1.92765	-2.2863	-1.09696	-1.19184	-3.79261	-4.04565	-0.80659	-1.25817
Croatia	-2.73239	-3.06194	-2.86205	-2.12147	-1.1455	-1.53685	-1.55451	-1.48097
Czech Rep	-3.07183	-3.26997	-2.34083	-2.60439	-5.08717	-5.32178	-0.94193	-1.17083
Estonia	-3.16519	-3.5007	-2.1131	-2.214	NA	NA	-2.48306	-2.79056
Hungary	-2.95411	-3.21105	-1.97082	-2.21796	-2.71394	-2.52225	-2.04056	-1.79491
Latvia	-3.07278	-3.44538	-3.26643	-3.075	NA	NA	-1.23313	-1.64979
Poland	-3.50446	-2.81944	-1.81445	-1.69243	-4.22463	-3.04478	-2.3068	-2.41106
Romania	-3.45844	-3.70157	-1.54663	-1.36185	-2.27266	-1.92563	-2.30896	-1.60889
Russia	-3.80957	-4.04263	-2.91808	-3.26279	-4.65152	-4.87127	1.918541	0.357784
Slovakia	-3.67081	-3.98627	-2.41378	-2.35487	-5.34787	-5.54157	-0.5579	-0.66329
Slovenia	-3.41785	-3.71423	-1.59955	-1.10667	NA	NA	-1.57186	-1.85226
West	-3.93104	-4.12197	-2.13493	-2.35328	-4.22444	-4.38557	-2.59875	-2.00999

the short sample size compared to the large number of parameters to be estimated. The selected order of the VARX model through SB criterion is shown in table(2).

As it can be seen for most of the countries a VARX (2,1) model is selected. The only exceptions are Estonia, Latvia, Romania, Slovakia and Slovenia for which a VARX (1,1) model is selected. Given that most of the variables are non-stationary, Johansen's cointegration test is conducted next in order to determine the number of cointegrating relations for each country. Here, the specifications consider case IV according to Pesaran et al. (2000), where a linear deterministic trend is implicitly allowed for the cointegration space but can be eliminated in the dynamic part of VEC models. The number of cointegration relations for each country based on the trace statistics is also shown in table(2). Most countries seem to

Table 2: Order of the VARX models and number of cointegrating relations

	p_i	q_i	Cointegrating relations
Bulgaria	2	1	1
Croatia	2	1	2
Czech Rep.	2	1	1
Estonia	1	1	1
Hungary	2	1	1
Latvia	1	1	2
Poland	2	1	1
Romania	1	1	1
Russia	2	1	1
Slovakia	1	1	2
Slovenia	1	1	0
West	2	1	2

have either two or one cointegrating relations except West and Slovenia, where the number of cointegrating relations are three and zero respectively. Next, individual country specific VECMX models were estimated subject to the reduced rank restrictions and the corresponding error correcting terms were derived. These ECM's were subsequently used to conduct the weak exogeneity test.

3.3 Weak exogeneity test

As mentioned earlier, one of the main assumptions of the GVAR model is the weak exogeneity of the country specific foreign variables $y^*_{i,t}$. In general, a variable in a VARX model is considered weakly exogeneous if it is not dependent on the contemporaneous values of the endogeneous variables but is likely to depend on the lagged values of these endogenous variables. More formally, $y^*_{i,t}$ is considered weakly exogenous if $y_{i,t}$ does not affect $y^*_{i,t}$ in the long run but $y^*_{i,t}$ is said to be 'long run forcing' for $y_{i,t}$. As shown in Johansen (1992), this assumption allows proper identification of the cointegration relations. In the formal test, joint significance of the estimated error correction terms in auxiliary equations for the country specific foreign variables $y^*_{i,t}$ is tested. Specifically, for each lth element of $y^*_{i,t}$ a regression of the following form in conducted:

$$\Delta y^*_{i,t,l} = a_{i,l} + \sum_{j=1}^{r_i} \delta_{i,j,l} \widehat{ECM}_{i,j,t-1} + \sum_{s=1}^{p^*_i} \phi'_{i,s,l} \Delta y_{i,t-s} + \sum_{s=1}^{q^*_i} \Psi_{i,s,l} \Delta \widetilde{y}^*_{i,t-s} + \eta_{i,t,l} (9)$$

where $\widehat{ECM}_{i,j,t-1}$, for $j = 1, 2, ..., r_i$ are the estimated error correction terms corresponding to the r_i cointegrating relations found for the i th country, and p^*_i and q^*_i are the orders of the lagged changes for the domestic and foreign variables respectively. The test for the weak exogeneity is an F-test of the joint hypothesis that $\delta_{i,j,l} = 0$ for $j = 1, 2, ..., r_i$ in the above equation. It is not necessary that lag orders of p^*_i and q^*_i are the same for the underlying country specific model. They are selected using the SB criterion.

The results are shown in table (3). As can be seen, all the variables pass the weak exogeneity test as the assumption of exogeneity can not be rejected at 5% level. This a very desirable result as it confirms the suitability of a GVAR model for this region.

Table 3: Weak exogeneity test

Country	F test	Fcrit_0.05	GROWTH	TB	CF	REER
Bulgaria	F(1,33)	4.139252	0.024466	0.00378	0.310812	0.050833
Croatia	F(2,32)	3.294537	0.067587	0.18637	0.009699	0.918436
Czech Rep.	F(1,33)	4.139252	0.29411	0.338994	0.194505	0.291681
Estonia	F(1,35)	4.121338	0.124685	0.995207		0.869943
Hungary	F(1,33)	4.139252	0.224262	0.016369	0.021007	0.970572
Latvia	F(2,34)	3.275898	2.833562	0.737852		0.032822
Poland	F(1,33)	4.139252	0.443411	0.515288	1.479342	0.013789
Romania	F(1,33)	4.139252	0.457485	2.180967	0.021287	0.149393
Russia	F(1,33)	4.139252	1.543514	0.230561	0.027878	1.125398
Slovakia	F(2,32)	3.294537	0.74759	0.649873	0.725438	2.032728
Slovenia	F(0,36)	4.139252	1.681344	0.007876		0.005241
West	F(3,31)	2.911334	1.403722	1.644399	1.198224	0.608457

3.4 Persistence profiles and stability

Another important condition for the GVAR system to work properly is the convergence of its persistence profiles. Persistence profiles (PPs) refer to the time profiles of the effects of system or variable-specific shocks on the cointegrating relations in the GVAR model (Pesaran and Shin (1996)). The persistence profiles (PP) give important information about the long run properties of the GVAR system and about the speed with which the cointegrating relations revert to their equilibrium states. As mentioned in Dees et al. (2007), in order to calculate the persistence profiles, consider the GVAR(p) model given by (8). The moving average representation of this model can be written as:

$$y_t = d_t + \sum_{s=0}^{\infty} A_s \varepsilon_{t-s} \tag{10}$$

$$= \varepsilon_t + A_1 \varepsilon_{t-1} + A_2 \varepsilon_{t-2} + ...$$

Here d_t is the deterministic part of y_t. A_s is derived recursively as

$$A_s = \sum_{s=1}^{\infty} F_i A_{s-i} \tag{11}$$

with $A_0 = I_m$, $A_s = 0$ for $s < 0$ Using the identity $z_{i,t} = W_i y_t$, equation (10) can be written as,

$$z_{i,t} = W_i d_t + W_i A_0 \varepsilon_t + \sum_{s=1}^{\infty} W_i A_s \varepsilon_{t-s} \tag{12}$$

In a GVAR context, the variable $\beta_i^{'} z_{i,t}$ represents the cointegrating relations in terms of the country specific variables. The PP's of $\beta_i^{'} z_{i,t}$ with respect to a system wide shock to ε_t are calculated as:

$$\mathcal{PP}(\beta_{j,i}^{'} z_{i,t}; \varepsilon_t, n) = \frac{\beta_{ji}^{'} W_i A_n \sum_{\varepsilon} A_n^{'} W_i^{'} \beta_{ji}}{\beta_{ji}^{'} W_i A_0 \sum_{\varepsilon} A_0^{'} W_i^{'} \beta_{ji} (13)}$$

for $n = 0, 1, 2, ...$ Where $\beta_{j,i}^{'}$ is the jth co-integrating relation in the ith country ($j = 1, 2, ..., r_i$). $\sum_{\varepsilon}$ is the covariance matrix of ε_t. The A_n matrices are calculated based on (11).

PP's have a value of unity on impact and should converge to zero in the long term, which implies that the system will return to its long run equilibrium after a system wide shock. The results are shown in figure (1). Though GVAR studies generally use a 40 quarter period within which the PP's should go to zero, the results here show that PP's are converging to zero within a 15 quarter period. This provides valuable evidence on the validity of the chosen long-run relations.

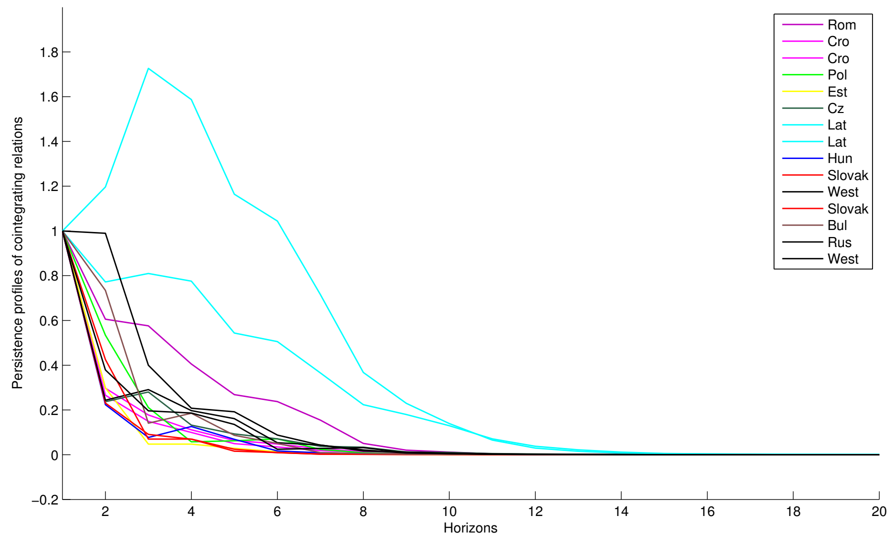

Figure 1: Persistence profiles of cointegrating relations

The stability of the GVAR model can be determined from the eigenvalues and corresponding moduli, which characterize the dynamic properties of the model. These values should lie inside and at most on the unit circle in order for the model to be stable. Results in table (5) in the appendix show that the modulus of every eigenvalue of the GVAR is on or within the unit circle. This proves that the model in consideration is stable.

3.5 Time varying trade weights

As mentioned in section 2, trade weights are calculated for each country in order to create the country specific foreign variables. These trade weights reflect the proportion of a country's trade with other countries in the sample. Yearly bilateral trade flow data among each of the countries are used in order to create these weights. Use of time varying trade weights (instead of fixed trade weights) in this GVAR model means there are trade weights for each country for each year in the sample. This large trade weight matrix give insights on how trade flow fluctuated between countries over the years. Since the main aim of this research is to compare the effects of Russia and Western European countries on CEE-Baltic countries, fig.2 summarizes the relative trade weights of these two blocks for each CEE-Baltic countries. It shows the difference between Western European trade weight and Russian trade weight for each year. A higher number indicate higher trade volume with Western European countries compared to Russia.

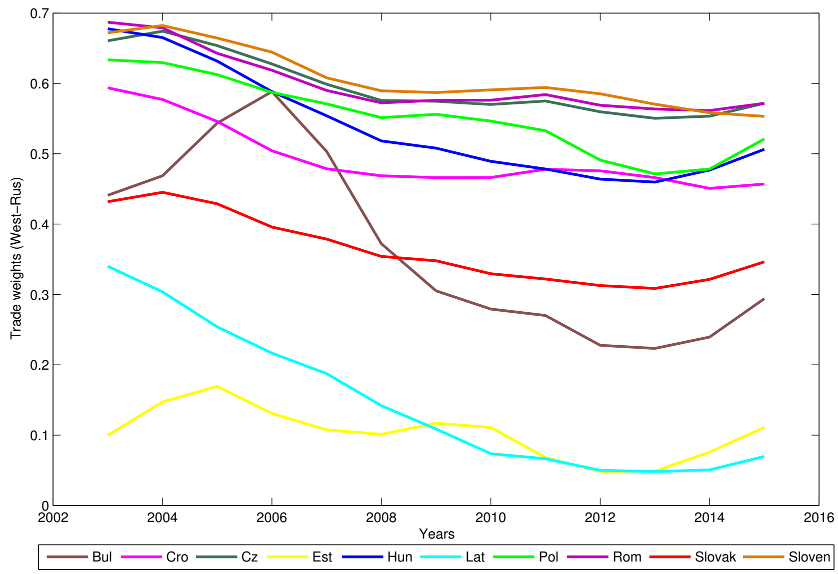

Figure 2: Difference in West and Russian trade weights for the CEE-Baltic countries

As it can be seen in the figure, the graphs show a slightly downward trend for almost all countries. This indicates that the share of Western European trade compared to Russia has been decreasing over the sample period for the CEE-Baltic countries. However, from 2014 there is an upward movement in the graphs, indicating a shift in the trend due to the economic sanctions on Russia. Only exception is Slovenia, which does not show much change after the sanctions. This is not very surprising as Slovenia also has the highest position in the graph for most of the years, indicating a weaker trade relationship with Russia compared to Western European countries. The low numbers for Estonia and Latvia show that the

Baltic countries in the sample have much stronger trade ties with Russia compared to CEE countries.

3.6 Contemporaneous effects

Contemporaneous effects show how variables of each country are affected contemporaneously by the combined effect of the same variables of the rest of the countries. These results are presented in table (4). Values of the coefficients show the response of the domestic country variable to a 1% change in their foreign counterpart. For example, in Bulgaria, a 1% increase in growth in the rest of the countries (foreign growth variable) brings 0.68% increase in growth in the domestic economy. These results can also be interpreted as impact elasticity and they give a good indication of how interconnected the countries are.

In table (4) coefficients are also presented with their corresponding Newey-West heteroskedasticity and autocorrelation consistent t- ratios. Values in bold font indicates they are statistically significant at the 5% level. Results show that, as far as growth and real effective exchange rate are concerned, there is a high degree of contemporaneous co-movements among the countries. Growth is statistically significant for all the countries in the sample. For Croatia, Estonia, Hungary, Romania, Slovakia and Slovenia the impact elasticity for growth is more than one, which indicates a 1% growth in the rest of the countries brings a growth of more than 1% in the same quarter for these countries. This also indicates that these countries are more sensitive to foreign growth shocks. Slovakia shows the highest reaction (1.7%) to a foreign growth shock while Poland shows the least (0.44%). The impact elasticity for the real effective exchange rate is also statistically significant for 8 countries, which indicates a strong interconnection among currency movement in these countries. On the other hand, trade balance and capital flows do not show any statistically significant contemporaneous movement to a foreign shock of the same variables. The only exception is Slovakia, where the coefficients are small but significant. This indicates Slovakia is the country most influenced by foreign shocks among all the countries in sample.

4 Dynamic analysis

Although it gives some initial information, impact elasticities do not say anything about the dynamic interlinkages between the macroeconomic variables of different countries. It also fails to answer how CEE-Baltic countries react to a shock to Russia compared to a shock to Western European countries. This section discusses the dynamic analysis by the means of generalized impulse response functions (GIRF's) originally proposed by Koop et al. (1996) and further developed by Pesaran and Shin (1998). The orthogonalised impulse response functions (OIRF'S) generally used in traditional VAR analysis requires certain ordering of variables to achieve identification. This approach is not suitable for GVAR models as it will require ordering of not only the variables but also the countries. Furthermore, it is difficult to justify such ordering based on economic theory and empirical findings for such a large number of countries simultaneously. Identification of shocks in a GVAR model is further complicated due to the cross country interactions and high dimensionality of the model. The advantage of GIRF's is that they are invariant to the ordering of the countries and variables. This is very convenient for models like GVAR that involve many countries and variables. Here the identification is achieved not by economic theory but by considering a counterfactual exercise where the historical correlations of shocks are assumed as given. Though this makes economic interpretation of shocks difficult, it is less of a problem if the cross country residuals are not strong. Table (5) shows the average pairwise cross-country correlation of residuals. The values indicate very low residual correlations and none of the absolute values surpass 0.15. These results suggest that the individual shocks are not much affected by other shocks in this particular GVAR model.

Fig.3a shows the GIRF's for Bulgaria, Croatia, Czech Republic, Estonia and Hungary

Table 4: Contemporaneous effects

		GROWTH	TB	CF	REER
Bulgaria	Coefficient	0.688045	0.036496	0.003729	0.322138
	t-ratio_NeweyWest	**3.960516**	1.192342	0.527948	**2.443414**
Croatia	Coefficient	1.103971	-0.00409	0.011082	0.40267
	t-ratio_NeweyWest	**4.606501**	-0.31308	0.98616	**2.254952**
Czech Rep.	Coefficient	0.86486	0.060995	-0.01368	1.072489
	t-ratio_NeweyWest	**8.924052**	1.865971	-0.65717	**3.617035**
Estonia	Coefficient	1.505398	-0.00258		-0.15113
	t-ratio_NeweyWest	**5.062461**	-0.38135		-0.75693
Hungary	Coefficient	1.005411	0.050883	-0.00179	1.653413
	t-ratio_NeweyWest	**3.188825**	0.982581	-0.04848	**2.614163**
Latvia	Coefficient	0.835505	0.005332		-0.10501
	t-ratio_NeweyWest	**6.233331**	0.980903		-0.55937
Poland	Coefficient	0.447349	0.053038	-0.02985	0.612292
	t-ratio_NeweyWest	**2.790829**	0.98114	-0.80206	1.734629
Romania	Coefficient	1.349552	-0.11523	0.018193	0.801085
	t-ratio_NeweyWest	**4.602305**	-1.59729	1.271085	**2.30779**
Russia	Coefficient	0.737761	-0.44768	-0.1354	0.549909
	t-ratio_NeweyWest	**3.059065**	-0.48067	-0.68754	1.016656
Slovakia	Coefficient	1.74727	0.117572	-0.04486	0.605307
	t-ratio_NeweyWest	**6.004657**	**3.605831**	**-3.02867**	**3.381165**
Slovenia	Coefficient	1.337717	-0.01319		0.653871
	t-ratio_NeweyWest	**14.38366**	-1.12055		**7.137036**
West	Coefficient	0.764651	0.062086	-0.25753	0.215858
	t-ratio_NeweyWest	**9.259899**	0.394297	-0.43721	**2.855041**

to a 1% growth shock to Russia and West[5]. Fig. 3b shows the same for Latvia, Poland, Romania, Slovakia and Slovenia. For each country, reactions of growth (GROWTH), trade balance (TB), real effective exchange rate (REER) and capital flows (CF) are depicted for up to 20 quarters. The thick red line shows the response to a Russian shock and the thick blue line represents the response to a Western European shock. This enables us to compare the spillover effects coming out of this two neighboring blocks. The associated 90% bootstrap confidence bands [6] are also displayed by the broken red and blue lines respectively.

[Fig. 3a and 3b about here]

The results show that growth shocks in both Russia and the West have significant spillover effects on growth in CEE-Baltic countries. However, Russian shocks have much stronger and persistent effects compared to shocks coming out of West. Though Russian and Western growth shocks have similar effects on impact on growth of all CEE-Baltic countries, the effect of the Russian growth shock increases in the subsequent few quarters before falling again while the effect of the Western growth shock falls straight away after impact and becomes insignificant after 5-6 quarters. The only exception is Poland (which is also one of the largest East European countries in the sample) where the difference between Russian and Western growth shocks are much smaller.

[Fig.4 about here]

[5]Since the main objective of the paper is to find whether a shock to Russia or the West play a greater role in CEE-Baltic countries, only the shocks coming out of these two country groups are considered. Also, in the interest of brevity, only shocks to growth (Fig 3a-3b) and trade balance (Fig.5a-5b) is displayed. Individual country results to a shock to the real effective exchange rate and capital flows is also available on request)

[6]Computed on the basis of 1000 replications

In order to shed more light on the country wide differences on the reaction to growth to a growth shock to Russia and West, Fig.4 summarizes the left most columns of Fig. 3a and 3b [7]. This helps to depict which countries are affected more in terms of growth shocks. Additionally, reaction of Russian and Western growth to a shock to each other is also depicted. The black GIRF in the left panel shows the reaction of West to a shock to Russia and the black GIRF in the right panel shows the reaction of Russia to a shock to West. Two findings stand out from Fig.4. First of all, as expected, Russia is more influenced by a growth shock to West than the other way around. In fact, growth of West is least affected by a Russian growth shock and growth of Russia is most affected by a West growth shock compared to all CEE-Baltic countries in the sample. This implies, even though lack of growth in Russia due to sanctions or any other reasons likely will have some negative effect on the growth CEE-Baltic countries, it might not affect the growth of Western European countries much.

Secondly, Slovakia and Poland, on average, show the highest and lowest reaction respectively. The fact that Poland and Slovakia are two of the best performing economies in terms of growth in East Europe in spite of having different spillover effects indicates the different nature of growth for these two countries. While the growth of Poland is affected more by internal factors, external factors play a greater role for Slovakia. This is in line with Piatkowski (2013), who argued that the adaptation of Western institutions and social norms helped Poland to establish the rule of law, robust competition, free press and democracy more successfully than any other East European nation. As a result, it has an improved business climate and rapidly growing domestic market. Improved quality and quantity of education also helped to create better human capital. Due to its weaker external links, it was also one of the least affected countries during the financial crisis of 2007-08. Slovakia on the other hand was severely affected by the financial crisis. Prior to the crisis, Slovak GDP

[7] confidence bands are not shown for the sake of clarity

per capita increased from 43% of the EU-15 average in 2000 to 64% in 2008. After the crisis, the convergence process reduced significantly. Biea (2016) found foreign direct investment (FDI) as one of the key factors that affects the growth of Slovakia. Costaiche and Niculae (2016) have similar findings for Romania, which is another country in the sample with high growth rates and high spillover effects from Russia and West.

Effects of Russian and Western growth shocks to other variables are much smaller, temporary and in many cases insignificant. After a growth shock from Russia and West, the trade balance improves for Bulgaria, Czech Republic, Hungary and Slovakia but it falls for other CEE-Baltic countries. Here also Russian growth shocks have larger effects on CEE-Baltic countries than growth shocks from the West (the only exception is Estonia). In terms of magnitude, these effects are small (usually not more than 0.2%) after a growth shock and they are significant for only the first few quarters. Exceptions are Latvia and Romania, where the trade balance decreases by about 0.5% after the growth shock to Russia. Effects on the real exchange rate after a growth shock is also small but varies a lot between countries. There is currency appreciation in the Czech Republic, Hungary, Poland and Romania following a growth shock in Russia and the West. For other countries, the currency depreciates. These results are again significant in the short term only. In terms of magnitude, the effect is smaller in countries like Latvia, Estonia, Slovenia and Slovakia while much higher in Hungary and Poland. For most CEE-Baltic countries, Russian growth shocks once again have a stronger effect on the real effective exchange rate compared to Western growth shocks. Capital flows on the other hand shows no significant movement after a growth shock in Russia and West.

[Fig. 5a and 5b about here]

Fig. 5a-5b show the reaction of a positive 1% trade balance shock to Russia and Western European countries for the same countries and variables. These shocks surprisingly have no significant effect on growth of each country. This indicates that the trade balance in Russia and West play very little role in the transmission of growth spillover effects found earlier. A positive trade balance shock in Russia and West however has different effects on the trade balance of different countries. A trade balance shock in Russia positively affects the trade balance in Bulgaria, Estonia, Hungary and negatively in Croatia, Romania and Slovenia. These reactions are, however, very small and short lived. A trade balance shock in West affects the trade balance of Bulgaria, Czech Republic, Hungary and Slovenia positively and Croatia, Romania and Slovakia negatively. For others results are insignificant. This shows the trade channel is weak and works differently for different CEE-Baltic countries. Though a trade balance shock appreciates the currencies for most of the CEE-Baltic countries, in most cases this effect is again negligible or insignificant.

5 Concluding remarks

The economic integration of CEE-Baltic countries has been a matter of great debate and discussion not only within these countries but also among Russia and the Western countries. The question whether these countries are more influenced by Russia or the West remains unanswered in many respects. This paper tries to investigate this question on economic grounds by comparing the spillover effects of growth and trade balance shocks in Russia and three major Western European countries on 10 CEE- Baltic countries using a GVAR model. The sample period 2003Q1-2015Q3 is particularly interesting as it contains both the financial crisis of 2007-08 and the recent economic sanctions on Russia. Therefore, a time varying weight has been used in order to capture the volatility in the data during these periods. This weight matrix is used to create the foreign variables for individual countries that provide a connection between the evolution of domestic variables and other countries in the sample. In addition to GDP growth, each country models also include the trade balance, real effective exchange rate and capital flows as endogenous variables which may function as potential transmission mechanism of growth.

The results show that growth spillover effects are significant across countries. However, growth shocks to Russia have a larger and more persistent effect on growth of CEE-Baltic countries than growth shocks to Western European countries. This is also true for trade balance shocks, however the effect of this shock is very limited and insignificant in many cases. A closer look at the spillover effects of growth shocks reveals that Russia is affected more by shocks to West than the other way round. In fact, growth spillover effects from West to Russia is higher than any CEE-Baltic countries. Similarly growth spillover effects from Russia to West is lower than all the CEE-Baltic countries. Among the CEE-Baltic countries, on average, Slovakia and Poland show the highest and lowest response to growth shocks from Russia and West. The fact that these two countries are also two of the most strongly growing nations in East Europe shows that growth processes are different for different countries. While countries like Slovakia are more responsive to external shocks, growth of countries like Poland are more due to domestic factors. Poland is also the country where the difference in growth from a growth shock to Russia and West is the lowest.

These results have important policy implications especially in today's tense geo-political situation. It implies if growth is affected in both Russia and Western Europe by sanctions and counter sanctions, Russia will relatively suffer the greater loss. On the other hand, CEE-Baltic countries will also suffer due to their higher sensitivity to Russian growth shocks. As many of these countries are members of NATO and the EU, the Western countries might also want to take this into account while taking decisions on sanctions. The results also imply that even if the growth rate is high, each country can have different growth mechanisms. As a result they should take decisions on economic integration based on their own strength. Finally, future studies could investigate the role of other macroeconomic and financial variables in the transmission of growth shocks.

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Figures and tables

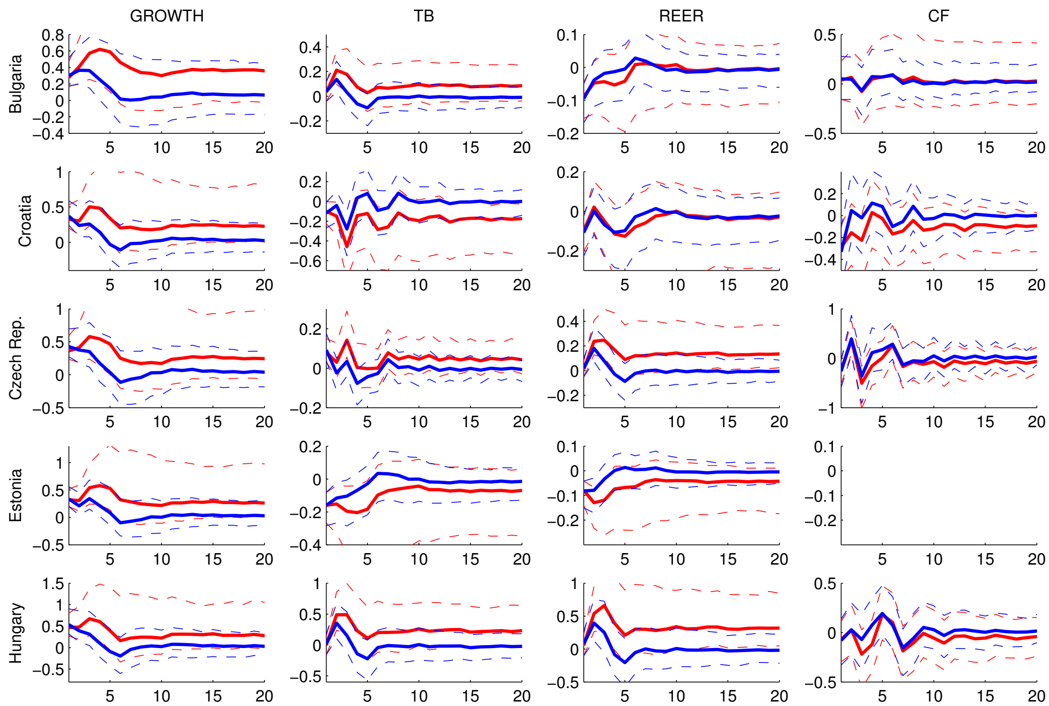

Figure 3a: Impulse response functions for an expansionary 1% shock to Russia GDP growth (red) and West GDP growth (blue) for Bulgaria, Croatia, Czech Republic, Estonia and Hungary. *Notes:* The figure reports general impulse response functions (GIRFs) for the GDP growth rate (GROWTH), trade balance (TB), real effective exchange rate (REER) and capital flows (CF). The graphs show bootstrap median estimates with the associated 90% bootstrap confidence bands computed on the basis of 1000 replications of the GIRFs, where the forecast horizon extends up to 20 quarters and is recorded along the horizontal axis.

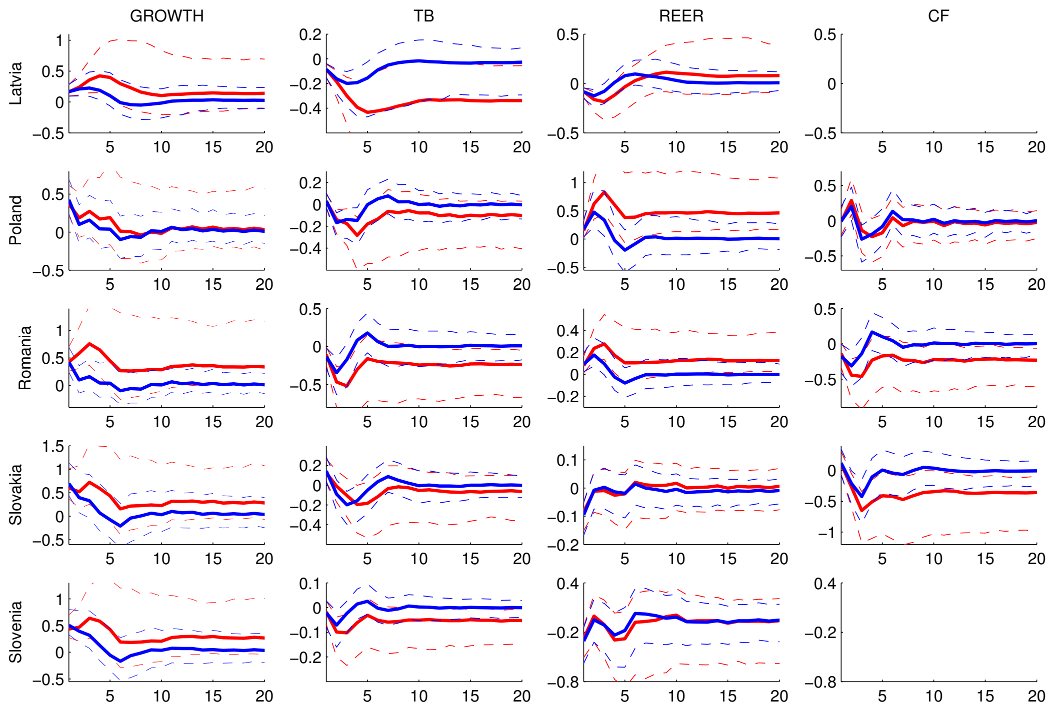

Figure 3b: Impulse response functions for an expansionary 1% shock to Russia GDP growth (red) and West GDP growth (blue) for Latvia, Poland, Romania, Slovakia, Slovenia. *Notes: See Fig.2a*

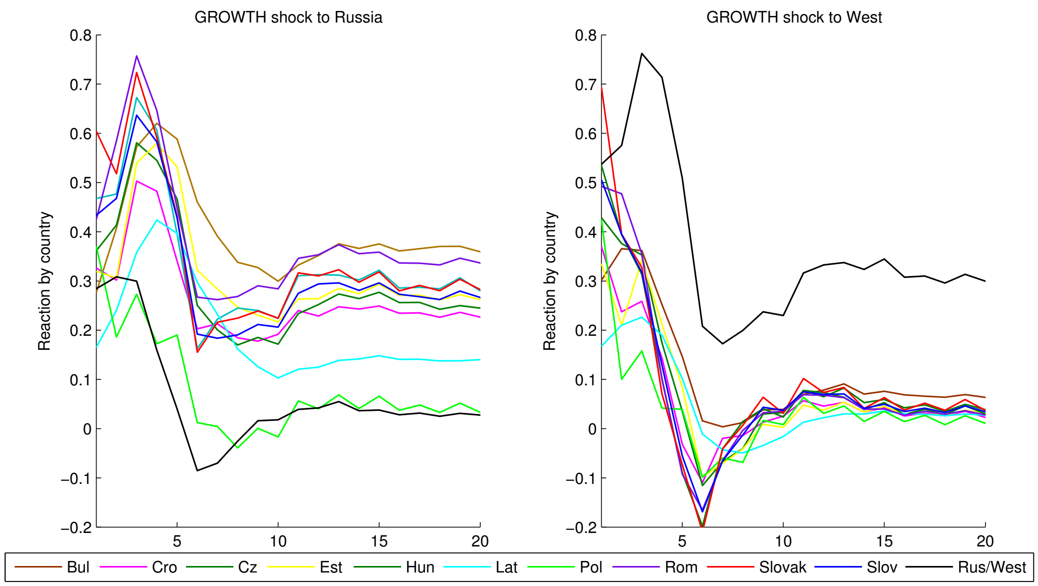

Figure 4: Generalized impulse response functions for an expansionary 1% shock to Russia GDP growth (left panel) and West GDP growth (right panel) to GDP growth of Bulgaria (Bul), Croatia (Cro), Czech Republic (Cz), Estonia (Est), Latvia (Lat), Poland (Pol), Romania (Rom), Slovakia (Slovak), Slovenia (Slov), Russia (Rus) and West (West).

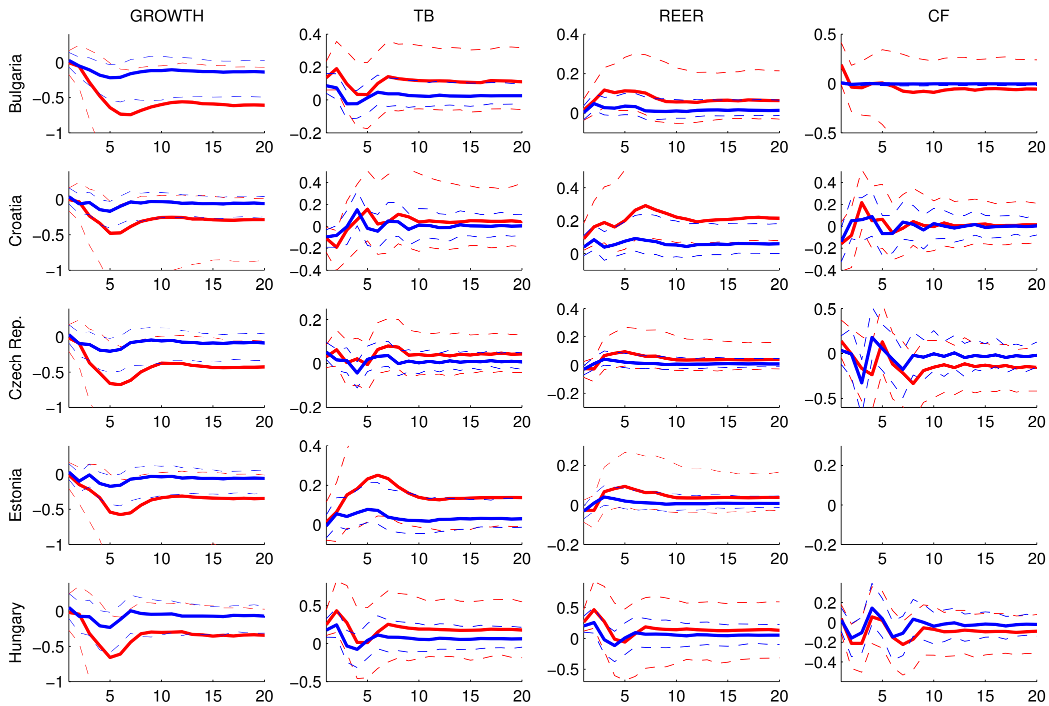

Figure 5a: Impulse response functions for an expansionary 1% shock to Russia trade balance (red) and West trade balance (blue) for Bulgaria, Croatia, Czech Republic, Estonia and Hungary.*Notes: See Fig.2a*

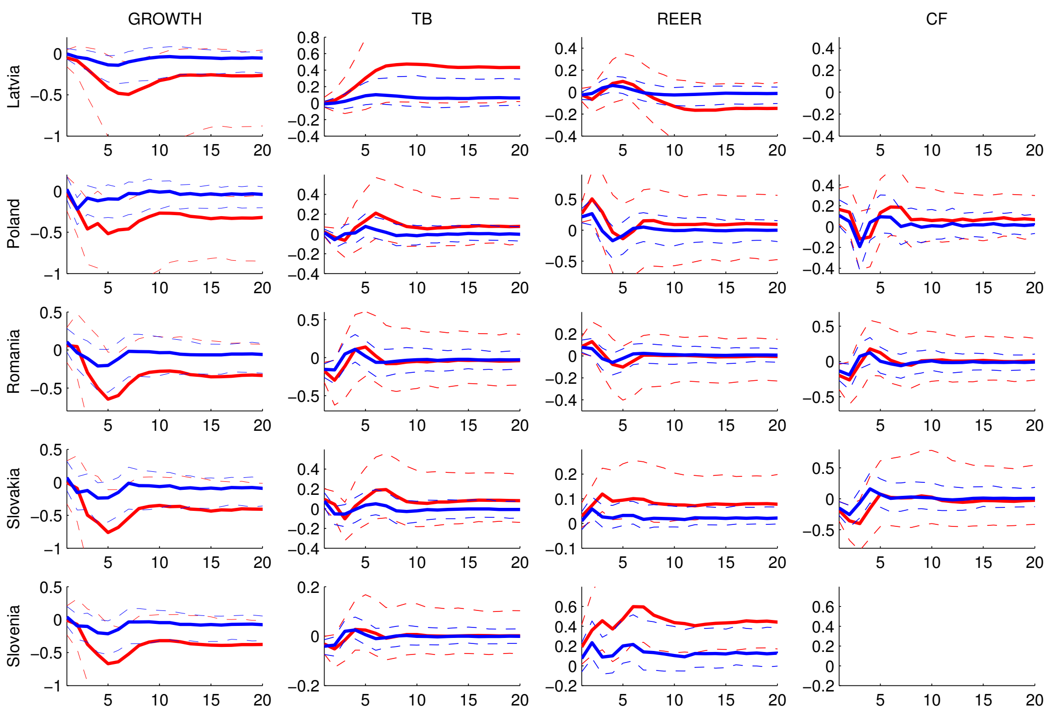

Figure 5b: Impulse response functions for an expansionary 1% shock to Russia trade balance (red) and West trade balance (blue) for Latvia, Poland, Romania, Slovakia, Slovenia. *Notes: See Fig.2a*

Table 5: Average pairwise cross-country correlations of residuals

	GROWTH	TB	CF	REER
Bulgaria	0.020151	0.043271	-0.041	0.082313
Croatia	-0.01089	0.041577	-0.09971	0.05627
Czech Rep.	0.058946	0.002078	0.00487	-0.01286
Estonia	0.014506	0.033282		0.127828
Hungary	-0.15136	0.017518	-0.03838	-0.05192
Latvia	-0.07093	0.137989		0.103944
Poland	-0.11155	0.034213	-0.00969	-0.03415
Romania	0.017433	-0.00093	-0.02948	-0.07287
Russia	-0.02615	0.02859	-0.00992	-0.14357
Slovakia	0.02162	0.000284	-0.05965	0.089769
Slovenia	0.05451	0.026772		0.039746
West	-0.06615	-0.02497	-0.0531	0.086245

Table 5: Eigenvalues of the GVAR Model and their corresponding moduli

Eigenvalues of the GVAR Model in Descending Order	Corresponding Moduli
1	1
1	1
1.00000000000001 +0.00000000000000i	1
1.00000000000001 -0.00000000000000i	1
1.00000000000001 +0.00000000000001i	1
1.00000000000001 -0.00000000000001i	1
1	1
1.00000000000000 +0.00000000000000i	1
1.00000000000000 -0.00000000000000i	1
1	1
1.00000000000000 +0.00000000000000i	1
1.00000000000000 -0.00000000000000i	1
1	1
1	1
1	1
1	1
1	1
1.00000000000000 +0.00000000000000i	1
1.00000000000000 -0.00000000000000i	1
1	1
1.00000000000000 +0.00000000000000i	1
1.00000000000000 -0.00000000000000i	1
1	1
1.00000000000000 +0.00000000000004i	1
1.00000000000000 -0.00000000000004i	1
0.99999999999999 +0.00000000000000i	1
0.99999999999999 -0.00000000000000i	1
0.99999999999998 +0.00000000000002i	1
0.99999999999998 -0.00000000000002i	1
0.79496187187708 +0.15491520759545i	0.809915
0.79496187187708 -0.15491520759545i	0.809915
0.73062	0.802199

Table 5: Eigenvalues of the GVAR Model and their corresponding moduli...(continued)

Eigenvalues of the GVAR Model in Descending Order	Corresponding Moduli
0.05426023200731 -0.09294047651452i	0.546356
0.016795	0.538889
0	0.538889
0	0.515553
0	0.515553
0	0.507597
0	0.507597
0	0.477802
0	0.477802
0	0.448058
0	0.398067
0	0.398067
0	0.342673
0	0.295667
0	0.295667
0	0.23792
0	0.216814
0	0.204616
0	0.189323
-0.07511367476027 +0.61986486595398i	0.189323
-0.07511367476027 -0.61986486595398i	0.159172
-0.08971	0.138152
-0.09769840614870 +0.46770702822765i	0.113489
-0.09769840614870 -0.46770702822765i	0.10762
-0.11349	0.10762
-0.12054144392697 +0.79309106115594i	0.089712
-0.12054144392697 -0.79309106115594i	0.016795
-0.12669779022318 +0.37736597981954i	0
-0.12669779022318 -0.37736597981954i	0
-0.15917	0
-0.18917697913908 +0.00743902349442i	0
-0.50694274213504 +0.09382747292227i	0
-0.50694274213504 -0.09382747292227i	0