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A Global Macro Model for Emerging Europe

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Editorial

This paper puts forward a global macro model comprising 43 countries and covering the period from Q1 1995 to Q4 2011. The author’s regional focus is on countries in Central, Eastern and Southeastern Europe (CESEE) and the Commonwealth of Independent States (CIS). Applying a global VAR (GVAR) model, he is able to assess the spatial propagation and the time profile of foreign shocks to the region. The author’s results show that first, the region’s real economy reacts nearly equally strongly to an U.S. output shock as it does to a corresponding euro area shock. The pivotal role of the U.S.A. in shaping the global business cycle thus seems to partially offset the region’s comparably stronger trade integration with the euro area. Second, an increase in the euro area’s short-term interest rate has a negative effect on output in the long run throughout the region. This effect is stronger in the CIS as well as in Southeastern Europe, while it is comparably milder in Central Europe. Third, the region is negatively affected by an oil price hike, with the exception of Russia, one of the most important oil exporters worldwide. The oil-driven economic expansion in Russia seems to spill over to other – oil-importing – economies in CIS, thereby offsetting the original drag brought about by the hike in oil prices. Finally, the author’s results corroborate the strong integration of advanced economies with the global economy. By contrast, the responses in emerging Europe are found to be more diverse, and country-specifics seem to play a more important role.

September 23, 2013

A Global Macro Model for Emerging Europe*

Martin Feldkircher†

September 5, 2013

Abstract

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Keywords: Global VAR, transmission of international shocks, Eastern Europe, CESEE, great recession, emerging Europe, global macro model, foreign shock.

JEL classifications: C32, F44, E32, O54.

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1 Introduction

Central, Eastern and Southeastern Europe (CESEE) saw rapid economic growth in the years preceding the global financial crisis. The remarkable growth process was accompanied by a steady rise in trade integration with the EU. When the global financial crisis started to unfold, however, growth abruptly stalled. Strong economic ties with Western Europe exposed the region to stress emanating from the global economy. This development highlights the importance of analyzing the CESEE countries in a global context, in particular in a way that allows to model repercussions caused by the global economy.

The literature on the effect of foreign shocks to CESEE's real economy is rather limited. Surprisingly, academic contributions that asses the region's response to a shock in *foreign output* are even more scarce. Jiménez-Rodriguez et al. (2010) provide the most coherent contribution, using monthly data to examine the impact of various foreign shocks on domestic industrial production via structural near-VAR models. They show for ten Central Eastern European (CEE) countries that industrial production rises significantly after a positive shock to industrial production in the euro area. Strikingly, this effect is even larger if the shock originates in the U.S.A. While the effects of a commodity price shock are found to be rather mixed, a positive shock to euro area interest rate curbs industrial production in the majority of the countries in their sample. Other - country-specific - contributions examining foreign shocks comprise Caraiani (2008), who uses a structural DSGE model to assess the effects of foreign shocks to the Romanian economy. According to his results, euro area demand and interest rate shocks have a moderate impact on domestic output, while supply and interest rate shocks exert a significant and persistent impact on the price dynamics in the economy. Krznar and Kunovac (2010) use a structural VAR to assess the impact of a GDP shock in the EU on the Croatian economy. They find that a 1% increase in EU GDP boosts the Croatian GDP by an astonishing 2% in the long run and conclude that EU GDP shocks are the key determinants of domestic real activity.

Recently, the examination of growth spillovers to Eastern Europe has gathered the attention of policy institutions. In its Spillover Report (see IMF, 2012), the IMF estimates that a 1% GDP shock to Western Europe adds on average about 0.4 to 1% to output in CESEE, depending on the methodological framework. The EBRD estimates country-specific VARs and introduces external shocks as additional regressors into the corresponding models (see Chapter 2 in EBRD, 2012). Their results reveal Ukraine as the economy that is most vulnerable to fluctuations in euro area output, followed by the Baltic States. By contrast, more resilient economies are Slovakia and Poland. Note that while IMF (2012) ignores country specifics by modeling Eastern Europe as a regional block, EBRD (2012) uses VAR regressions on a country-by-country basis and the most recent data (including Q4 2011). Both policy notes, however, fail to take intra-regional spillovers into account, which play an important role for Eastern Europe.

The literature on foreign monetary policy shocks is more abundant. Benkovskis et al. (2011) examine foreign monetary policy shocks for the Czech Republic, Hungary and Poland. Based on a factor-augmented VAR model, Benkovskis et al. (2011) show that the response to a positive euro area interest rate shock is negative and significant for these three countries. Minea and Rault (2011) focus on external monetary shocks and their repercussions for

Bulgaria's macro economy. They show that domestic variables are less sensitive to an ECB interest rate shock compared to a monetary shock from the U.S. Federal Reserve. Horváth and Rusnák (2009) investigate the response of Slovakia to a monetary policy shock emanating from the euro area. They find a strong relationship between foreign and domestic interest rates. However, monetary policy shocks, both foreign and domestic, in general exert little influence on the Slovak output gap which in turn is largely driven by (other) domestic factors. Jarociński (2010) examines the monetary policy transmission in four Central Eastern European (CEE) countries and compares them to five Western European countries. Using a structural VAR approach, he concludes that the response of the output gap to a domestic monetary policy shock is broadly similar in the two sets of countries. The domestic interest rate in the CEE countries, however, reacts comparably more strongly to the shock. For further contributions regarding the transmission of monetary policy see, among others Coricelli et al. (2006), Égert and MacDonald (2009), and Vonnák (2010).

The empirical analysis of spillovers reviewed above is closely related to the examination of the countries' integration with the global economy. Some studies focus on the cross-country correlation of impulse-response functions to an external shock – others on the synchronization of the business cycles with e.g., the euro area. Fidrmuc and Korhonen (2006) perform a meta-analysis and conclude that some CEE economies are strongly synchronized with the euro area. Moreover, they find that empirical results are shaped by the estimation method employed. Darvas and Szapáry (2008) use different detrending methods and five measures to assess cross-country co-movements in quarterly GDP series. They conclude that Hungary, Poland and Slovenia have achieved a high degree of synchronization, whereas the Czech Republic and Slovakia are less synchronized. Artis et al. (2008) analyze drivers of business cycle co-movements based on quarterly GDP series. In line with results of Darvas and Szapáry (2008) they find that the Czech Republic and Slovakia are less synchronized with the euro area, while the opposite holds true for Hungary, Poland and Slovenia. Aslanidis (2010) examines the potential for asymmetries in the business cycles' co-movements using monthly data on industrial production. Based on a threshold approach he finds evidence for a contraction and one expansion regime. He concludes that most CEE economies are synchronized with the euro area.

Studies using more recent data provide mixed evidence. Adalet and Öz (2010) employ vector autoregressions to assess whether the business cycles of five CEE countries are more synchronized with those of the U.S.A., Germany or Russia. They conclude that the Czech, the Polish and the Hungarian economy are more closely linked to the U.S. business cycle whereas the Slovakian business cycle is the only one to be more synchronized with the German business cycle. Matesanz Gómez et al. (2012) use a network approach and find different clusters of countries. More specifically, a pronounced degree of co-movement with Western Europe has been achieved in the Baltic States, Poland, Slovenia and Turkey, while there was de-synchronization in Romania and Bulgaria. Hungary seems to be more synchronized with the Anglo-Saxon countries.

In this paper we extend the literature surveyed above in several ways. We are the first ones to deliver a consistent global macro model for emerging Europe, which we define in a broad way to cover economies from CESEE and the CIS. Using a global VAR (GVAR) model, we are able to go beyond the simple analysis of a single country's reaction to a foreign shock. Incorporating bilateral economic links, the GVAR framework put forward in Pesaran et al.

(2004) allows us to examine within regional spillovers, and consequently knock-on effects through economies that function as gatekeepers to the region. We furthermore extend the time series coverage to include the period of the recent global financial crisis. Since the real economy of the region was strongly affected by the crisis, extending our analysis over the period might yield further insights about how external shocks are transmitted trough the global economy. In this vein, we estimate the dynamic response of the real economy in emerging Europe to four different exogenous shocks. We contrast the response of the region to a positive shock to U.S. real output with the corresponding shock emanating from the euro area. We use a 50% increase in the oil price as a proxy for a hike in commodity prices and look into the response of the region, which consists of both oil exporters and importers. Finally, we include a shock to the euro area's short-term interest rate. The investigation of these four shocks allows us to assess the response of the real sector in these economies to a broad portfolio of external shocks.

The paper is structured as follows. Section 2 lays out the econometric framework and Section 3 illustrates the data. In Section 4 we present the main properties of our model together with a range of specification test. In Section 5 we carry out four macroeconomic shocks and present the results for CESEE and the CIS. Section 6 concludes.

2 Empirical Approach - The GVAR Model

We employ a global vector autoregressive (GVAR) model, which is a compact representation of the world economy and designed to model interlinkages between economies across the globe. In principle, a GVAR model comprises *two layers* via which the model is able to capture cross-country spillovers. In the first layer, separate time series models – one per country – are estimated. Typically, these time series models are in vector error correction (VECM) form since data on the macro economy often share common stochastic trends. In the second layer, the country models are stacked to yield a global model that is able to trace the spatial propagation of a shock as well as its time dynamics.

2.1 First Layer: The Country Models

We estimate the following system of equations for each country $i \in \{1, \ldots, N\}$ similar to Dees et al. (2007a):

$$\begin{aligned} \Delta y_t = & \quad c_{y0} + c_{y1}t + \Pi_y z_{t-1} + \sum_{k=1}^{p-1} \Gamma_{yy,i} \Delta y_{t-k} + \sum_{k=1}^{q-1} \Gamma_{yx,i} \Delta x_{t-k} && \text{(1a)} \\ + & \quad \sum_{k=1}^{lex-1} \Psi_i \Delta d_{t-k} + \Lambda_x \Delta x_t + \Lambda_d \Delta d_t + e_{yt} && \\ \Delta x_t = & \quad c_{x0} + c_x t + \sum_{k=1}^{p-1} \Gamma_{xy,i} \Delta y_{t-k} + \sum_{k=1}^{q-1} \Gamma_{xx,i} \Delta x_{t-k} + e_{xt} && \text{(1b)} \end{aligned}$$

with $z_t = (y_t, x_t)$, $u_t = (e_{yt}, e_{xt}) \sim N(0, \Sigma_u)$ and Δ denoting the first difference operator. We distinguish four different types of variables: domestic, foreign and global variables as well as deterministic trend components. First, the $m \times 1$ vector y_t contains the set of *domestic* (endogenous) variables. They typically comprise data on output, prices and other standard macroeconomic variables. The set of domestic variables is enlarged by the $n \times 1$ vector x_t of *foreign* (weakly exogenous) variables. Including foreign variables allows us to estimate the economy's sensitivity to movements in foreign factors. More specifically, for each country we construct the set of foreign variables as a cross-country weighted average of its domestic counterparts:

$$x_t^i := \sum_{j \neq i}^{N} \omega_{ij} y_t^j.$$

The weights $w_{ij} \in \mathbf{W}$ mirror the strength of economic relationships across countries and are typically based on bilateral trade flows (Dees et al., 2007a; Pesaran et al., 2004, 2007) or occasionally on financial flows (Sgherri and Galesi, 2009; Eickmeier and Ng, 2011; Backé et al., 2013). The corresponding $N \times N$ weight matrix $\mathbf{W}$ is row-standardized and has zero entries on its diagonal: $\omega_{ij} \geq 0, \quad \omega_{ii} = 0, \quad \sum_{j=1}^{N} \omega_{ij} = 1$. Recently, the use of time-varying weights $\mathbf{W_t}$ has been propagated (Cesa-Bianchi et al., 2012). This allows keeping track with the development of emerging economies and the accompanied shift in the balance of power in the world economy. Note that since N is typically large, it is not possible to include the domestic variables' foreign counterparts directly on a country-by-country basis.

We control for global factors such as oil prices by including *strictly exogenous* components d_t into the model. In the empirical application we forego the approach put forward in Dees et al. (2007a) or Pesaran et al. (2004, 2007) and opt for not including strictly exogenous variables in the long-run relationship. That is, similar to Lütkepohl (1993), we exclude strictly exogenous covariates as control variables from Π, which turns out to enhance the global stability of the model put forward in Section 4. Note that both weakly and strictly exogenous variables are allowed to enter the conditional model of Δy_t *contemporaneously*, while the domestic variables are included in lagged form only. Finally we include a trend and an intercept term which we might restrict to lie in the cointegration space.

Equipped with that notation we can rewrite the system of equations for country i more compactly as:

$$\Delta z_t = c_0 + c_1 t + \Pi z_{t-1} + \Lambda_x \Delta x_t + \Lambda_d \Delta d_t + \sum_{k=1}^{p-1} \Gamma_i \Delta z_{t-k} + \sum_{k=1}^{lex-1} \Psi_i \Delta d_{t-k} + u_t \qquad (2)$$

The long-run properties of the model are summarized in the matrix Π that can be (along Γ) partitioned as follows:

$$\Pi = \begin{pmatrix} \Pi_y \\ \Pi_x \end{pmatrix} = \begin{pmatrix} \Pi_{yy} & \Pi_{yx} \\ \Pi_{xy} & \Pi_{xx} \end{pmatrix}; \quad \Pi = \alpha\beta'$$

with α denoting the $(m+n) \times r$ adjustment or loading matrix, β the $(m+n) \times r$ matrix of coefficients attached to the long-run equilibrium and r the cointegration rank. In case the variables contained in z_t are cointegrating, the long-run matrix Π will be rank deficient. To be still able to identify the matrices α and β one typically uses the identity matrix to normalize the cointegration matrix. As a consequence, the structural parameters contained in β have to be interpreted as relative to the identification that was used in the forefront. This implies that β bears no economic meaning per se, while the magnitude of the coefficients can still yield insights with regard to which variable drives the long-run relationship (Juselius, 2006). Note that weakly exogenous variables are part of the cointegration space. We follow the convention made in the literature and assume that the foreign variables are 'long-run forcing' the endogenous variables but not vice versa. This assumption is fused into the model by setting $\Pi_x = 0$. The condition implies furthermore that the vector x_t does not contain common stochastic trends (Assenmacher-Wesche and Pesaran, 2009).

2.2 Second Layer: Stacking the Individual Country Models

Once we have estimated the N single country models outlined in equation 2 the models are transformed into their corresponding VAR representation and 'stacked' to yield a single global model.

Accordingly, we first re-write the model given in the set of equations in 1 into its VAR form:

$$(I, -B_0^i) \begin{pmatrix} y_t^i \\ x_t^i \end{pmatrix} = \tilde{c}_0^i + \tilde{c}_1^i t + \sum_{k=1}^{r_i} (A_k^i, B_k^i) \begin{pmatrix} y_{t-k}^i \\ x_{t-k}^i \end{pmatrix} + \sum_{k=0}^{lex_i} \tilde{\Upsilon}_k^i d_{t-k}^i + \tilde{u}_t^i, \tag{3}$$

where $r_i := \max(q_i, p_i)$ and the matrices A_k^i and B_k^i are defined to be zero for previously unused lags k.

More compactly, equation (3) can be written as

$$\tilde{G}^i z^i \;=\; \tilde{c}_0^i + \tilde{c}_1^i t + \sum_{k=1}^{r_i} \bar{H}_k^i z_{t-k}^i + \sum_{k=0}^{lex_i} \tilde{\Upsilon}_k^i d_{t-k}^i + \tilde{u}_t^i$$

Here $\bar{H}_k^i$ denote the stacked matrices of coefficients attached to endogenous and weakly exogenous variables. Note that these coefficient matrices denote estimates from the first layer of the GVAR model. We now invoke a $m_i \times \sum_{i=1}^N m_i$ global link matrix $\mathcal{W}^i$ that governs how shocks are propagated through the system:

$$\begin{aligned} \tilde{G}^i \mathcal{W}^i y_t &= \tilde{c}_0^i + \tilde{c}_1^i t + \sum_{k=1}^{r_i} \bar{H}_k^i \mathcal{W}^i y_{t-k} + \sum_{k=0}^{lex_i} \tilde{\Upsilon}_k^i d_{t-k}^i + \tilde{u}_t^i, \text{ or} \\ G^i y_t &= \tilde{c}_0^i + \tilde{c}_1^i t + \sum_{k=1}^{r_i} \tilde{H}_k^i y_{t-k} + \sum_{k=0}^{lex_i} \tilde{\Upsilon}_k^i d_{t-k}^i + \tilde{u}_t^i. \end{aligned}$$

$\mathcal{W}^i$ maps domestic to foreign variables by transforming the matrices of estimated coefficients H^i in such a way that links between all countries are established. Note that these links are typically the ones that were used to construct the foreign variables (i.e., contained in $\mathbf{W}$). However, in recent empirical contributions (e.g., Cesa-Bianchi et al., 2012) different sets of weights for the estimation stage and the solution stage of the GVAR model have been proposed. For example, elements in $\mathcal{W}^i$ can either constitute an average of trade flows or stem from different instances in time thereof. In the empirical application we follow Cesa-Bianchi et al. (2012) and use time-varying weights $\mathbf{W_t}$ to construct the foreign variables and trade flows from 2011 to stack the single models $\mathcal{W}^i_{2011}$.

Finally, we can stack the single country models:

$$Gy_t = \tilde{c}_0 + \tilde{c}_1 t + \sum_{k=1}^{r} \tilde{H}_k y_{t-k} + \sum_{k=0}^{lex} \tilde{\Upsilon}_k d_{t-k} + \tilde{u}_t, \tag{4}$$

where

$$r := \max_{i=1,\ldots,N} r_i, lex := \max_{i=1,\ldots,N} lex_i$$

and the matrices H_k and Υ_k are defined to be zero for previously unused lags k. The stacked square matrix G is non-singular so that equation (4) can be multiplied by G^{-1} from the left to yield the GVAR model:

$$y_t = c_0 + c_1 t + \sum_{k=1}^{r} H_k y_{t-k} + \sum_{k=0}^{lex} \Upsilon_k d_{t-k} + u_t, \tag{5}$$

The global model in equation 5 constitutes a compact empirical representation of the world economy with the economies linked in several ways: First, the model directly exploits (trade-) weights to mirror the interconnectivity between countries by calculating foreign variables on the one hand and by stacking the models together on the other hand. They are the most important channel by far through which spillovers are governed in the model. On top of that, countries are also connected through the dependence of domestic variables on global variables and finally through non-zero off-diagonal elements in the variance-covariance matrix Σ_u. Moreover, note that the way we have 'stacked' the single models within the second layer of the GVAR allows impulse response analysis that can cope with second- and higher-order interactions in the global system. It is thus important to bear in mind these ways of country connectivity the GVAR framework offers, when interpreting the empirical results provided in Section 5.

3 Data

We have extended the data set used in previous studies (e.g., Dees et al., 2007a; Pesaran et al., 2007) with respect to country coverage and time span. Our data set contains quarterly observations for 42 countries and 1 regional aggregate, the euro area (EA). It thus comprises emerging economies, advanced economies and the most important oil producers and consumers across the globe.

CEE (5):	CZ, HU, PL, SK, SI
SEE (6):	BG, RO, HR, AL, RS, TR
CIS and Mongolia (6):	RU, UA, BY, KG, MN, GE
Asia (9):	CN, KR, JP, PH, SG, TH, ID, IN, MY
Latin America (5):	AR, BR, CL, MX, PE
Rest of the World (12):	US, EA, UK, CA, AU, NZ, CH, NO, SE, DK, IS, EG

Table 1: Country coverage.

The country composition on which the data on the euro area is based changes with time. In other words, while historical time series are based on data of the ten original euro area countries, the most recent data are based on 17 countries. Nevertheless we report separate results for Slovenia and Slovakia since our regional focus rests on emerging Europe.[1] Together these $N = 43$ economies represented 90% of the global economy in 2010, which improves upon country coverage in Dees et al. (2007a), which amounted to 78% in the same year[2]. Since emerging economies typically grow fast, this coverage ratio is likely to further improve in the coming years.

We have also extended the time span covering the period of the global financial crisis. In particular, we have 68 quarterly observations for the period from Q1 1995 to Q4 2011. The global financial crisis started to unfold in end-2008, spilling to the real economy of emerging Europe in 2009. While Asian and Latin American emerging economies were pretty resilient to the crisis, some countries in emerging Europe significantly felt the real downturn. Therefore limiting the data span – as in other studies – to Q4 2009 would imply a downward trend in real activity at the end of the sample period for many countries. This does not apply for the time period covered here: While still feeling the repercussions of the global financial crisis, most countries showed positive growth rates and signs of recovery at end-2011. The *domestic* variables that are covered in our analysis comprise data on real activity, change in prices, the real exchange rate, and short- and long-term interest rates. We follow the bulk of the literature in including oil prices as a *global* control variable. By and large we include foreign output and foreign short- and long-term interest rates as weakly exogenous variables. A more detailed account on the choice of foreign variables is provided in Section 4. The data are briefly described in Table 2 below:

The inclusion of emerging European countries bears some important implications for the analysis. First, it limits the data span to the period starting from Q1 1995. Data prior to the countries' transformation from centrally planned to market economies is scarce, and even if data were available their interpretation would be cumbersome. Second, data on interest rates are scarce since local capital markets in parts of the region are still developing. This applies in particular to long-term interest rates, where the coverage ratio is 40% and thus rather low. Furthermore, in countries where domestic interest rates are non-existent, foreign interest rates play a particularly strong role, which then absorb all variation that would

[1]Our results remain qualitatively unchanged if we use instead of the rolling country composition for the data on the euro area a consistent set of 14 euro area member states throughout the sample period, as the relative economic size of the three excluded countries is quite small.

[2]Data refer to nominal GDP and are taken from the IMF's World economic outlook data base, April 2012.

Variable	Description	Min.	Mean	Max	Coverage
y	Real GDP, average of 2005=100. Seasonally adjusted, in logarithms.	3.465	4.509	5.092	100%
Dp	Consumer price inflation. CPI seasonally adjusted, in logarithms.	-0.258	0.021	1.194	100%
rer	Nominal exchange rate vis-à-vis the US dollar, deflated by national price levels (CPI).	-5.373	-2.039	5.459	97.70%
stir	Typically 3-months-market rates, rates per annum.	0	0.105	4.332	93%
ltir	Typically government bond yields, rates per annum.	0.007	0.060	0.777	39.5%
poil	Price of oil, seasonally adjusted, in logarithms.	-	-	-	-
Trade flows	Bilateral data on exports and imports of goods and services, annual data.	-	-	-	-

Table 2: Data description. Summary statistics pooled over countries and time. Coverage refers to the cross-country availability per country, in %.

otherwise be soaked up by domestic financial variables. Finally, data at the beginning of the sample period were missing for some countries. Similar to an expectation maximization algorithm, these values have been imputed. A more detailed account of the imputation method and the data sources is provided in the Appendix.

We proceed by examining the time series properties of the data. In order to pursue the outlined cointegration approach all time series should be integrated of order 1. We employ an augmented Dickey-Fuller test to the levels and first differences of all variables. Following Pesaran et al. (2004), we specify the ADF regression for the levels to include an intercept and trend term for real GDP, real exchange rates and oil prices. For non-trending variables, interest rates and inflation, the regression includes an intercept term only. The results are summarized in Table A1 in the Appendix. As expected, the unit root null hypothesis cannot be rejected for real GDP and real exchange rates. By contrast, interest rates and inflation do reject the unit root for some countries. Note that due to emerging Europe's strong trade ties with the euro area, its foreign long-term interest rates are largely determined by those of the euro area. The ADF test marginally rejects the null of a unit root for euro area long-term interest rates, which translates into a rejection of foreign interest rates in emerging European countries. We then investigate the unit root properties of the first-differenced data. Similar to Pesaran et al. (2004) we estimate the ADF regression here with an intercept term only. The results are provided in Table A2 in the Appendix. Most of the countries and variables reject the unit root. Thus we conclude that the variables are by and large integrated of order 1, which ensures the appropriateness of the econometric framework pursued in this study.

4 Model Setup

In this section we describe the specification of the GVAR model and carry out a range of diagnostic tests. There are several assumptions to be made when specifying the model, some of which are based solely on statistical grounds while others reflect the assumptions of the modeler about the interrelationships of the global economy.

We start with the latter and leave the former to the Appendix. First, we decide which variables are thought to *transmit* shocks from the global to the domestic economy. The strong co-movements of output and interest rates, in particular in crisis times, are well known. The empirical cross-country correlations for our data set are summarized in Table A3, left-hand-side panel. The average correlation for real output is 0.9, for of short-term interest rates 0.5, for long-term interest rates 0.7 and for inflation 0.2. We thus opt for constructing foreign variables for real output (**y***), short-term interest rates (**stir***) and long-term interest rates (**ltir***). The dominant role of the U.S.A., especially in financial markets, is mirrored in the assumption that spillovers take place via **y*** and **ltir*** only. That said, akin to Cesa-Bianchi et al. (2012), we opt for *time-varying* trade weights to construct these foreign variables. We furthermore base the matrix $\mathcal{W}$ on trade weights from 2011 to stack the single country models. By this we aim at reflecting the rising importance of key emerging economies such as China, Brazil, Russia and India, for the world economy.

We deviate in two instances from the standard GVAR literature that does not include data for emerging Europe. Since our data span is rather short, untreated outliers can have a serious impact on the overall stability and the results of the model. A range of our focus countries witnessed extraordinarily high interest rates at the beginning of the sample period, which returned steadily to 'normal' levels. Other countries (e.g., Russia, Argentina) were exposed to one-off crisis events. Leaving these events unnoticed can seriously affect the estimated elasticities and responses of the countries to foreign shocks. We have thus picked the largest deviations from 'normal' times per country and used linear interaction terms to take care of unusually large historical observations. The specification of the dummy variables is made available in the Appendix. Second, the modeling of oil prices deserves some further attention. Following the bulk of the literature we include oil prices as a domestic variable in the U.S. country model. Having oil prices determined within the U.S. model might be justified since the U.S. economy constitutes the largest oil consumer in the world by far. In contrast to Dees et al. (2007a), Pesaran et al. (2004), and Cesa-Bianchi et al. (2012), we opt for excluding the oil price as a control variable in the cointegration relationship. That is, it is assumed that the oil price has an impact on the short-run dynamics only. This assumption is relaxed for the largest oil producers Russia, Norway and Canada, as well as for the largest oil consumers, the euro area, Brazil, India and China.[3] For these countries we include the oil price in the form of a weakly exogenous variable - and thus as part of the cointegration relationship. Lastly, based on degrees-of-freedom considerations, we set the lag length for domestic, foreign and global variables to 1 for all economies. The standard intercept / trend and cointegration rank specifications are discussed in the Appendix.

[3]We opted for excluding oil prices from the cointegration relationship for Japan since this enhances overall stability of the global model. Results for Japan with the oil price included in the cointegration relationship are available from the author upon request.

This leaves us with the specifications summarized in Table A4. Before we present the dynamic analysis based on our final model specification, two diagnostic tests are carried out. First, we test whether it is appropriate to treat the foreign variables as weakly exogenous (i.e., $\Pi_x = 0$). Second, we test for serial autocorrelation in the country models. Both tests are F-tests and the results are provided in Tables A5 and A6 in the Appendix. The weak exogeneity test is based on auxiliary regressions for each of the foreign variables. More specifically, by regressing each foreign variable in a given country model on the error-correction term (and controlling for lags of the endogenous variables and the remaining weakly exogenous variables) one can examine whether the long-run relationship can explain the variation of the foreign variable that is scrutinized. The results provided in Table A5 in the Appendix corroborate the assumption to treat the foreign variables as weakly exogenous. At the 5% significance level this holds also true for the major economies, the U.S.A. and the euro area, as well as rising emerging economies, such as China, India and Brazil. In some country models, the F-test reveals significant error-correction terms at the 5% level. This indicates that the country's long-run relationship can shape variation in the foreign variable, thereby violating the weakly exogeneity assumption. However, the overall number of rejections is very small. Second, we look at a test of first-order autocorrelation in the residuals of the country models. Note that in macro models that are based on a quarterly frequency one would typically opt to include (at least) 4 lags. Since the number of parameters in the country models of the GVAR are typically large and given rather short time series we have set the lag length to 1 for all country models. The results of the F-test on first-order serial autocorrelation provided in Table A6 show that of 186 equations in the global model, 141 pass the test at the 5% significance level. In 163 equations, the hypothesis of no first order serial autocorrelation cannot be rejected at the 1% significance level. Although this result is quite encouraging, the results of the cross-country equations for real activity in the U.S.A. and the euro area are not as satisfactory. This leaves room for improvement if the data span increases in the future. Lastly we investigate the cross-country correlation of the country models as a further check. Since we control for foreign variables in the country models, the cross-country correlation of the residuals should be weak. This has some bearing, in particular on the interpretation of the generalized impulse functions we employ in the next section to see how the economies react to certain exogenous shocks. The results are provided in Table A3 in the Appendix. Accordingly, cross-country correlation is in general rather low. Only the equation of the real exchange rate shows correlations in the range of 0.3 to 0.4 for some countries.

5 Shock Scenarios

In this section we carry out four exogenous shocks to investigate the reaction of the real economy in emerging Europe. For that purpose we employ the *generalized impulse response* put forward in Pesaran and Shin (1998):

$$\mathrm{GIRF}(y_t, u_t, n) = \frac{F_n G^{-1} \Sigma_u s_j}{\sqrt{s_j' \Sigma_u s_j}} \tag{6}$$

with s_j a shock vector which contains the magnitude of the shock as its jth element and elsewhere zero, n the forecast horizon and F_n the dynamic multiplier matrix $F_n = \sum_{n=1}^{n} F_{n-1}(\sum_{i=1}^{max(p_i,q_i)} G^{-1}H_i)$. Σ_u denotes the variance covariance matrix of the GVAR model given in equation 5. There are several things worth noting: First, the impulse responses based on the GIRF are insensitive to the ordering of the variables in the system. This is in stark contrast to standard VAR analysis and might lead the analyst to prefer the GIRF. However, and due to its non-orthogonalized impulse response functions, the structural interpretation of the GIRF is limited. This is a general characteristic of the GIRF and is not a feature of the GVAR model.[4] The fact that the impulse responses under the GIRF are typically correlated renders necessary an investigation of the cross-country correlation of the residuals of the country models. As was shown in the previous section, these correlations are rather low. This in turn implies that there are no repercussions from other countries on the shock. That is, the shock diffusion can be traced back to the weights we have employed in the system (and are not driven by cross-country correlations of the shocks). However, note that while cross-country correlation of the residuals is weak, there is still a large degree of residual correlation among domestic variables within each country model. Therefore we abstain from giving the GIRF a structural interpretation. Finally, the impulse response analysis is based on the level of the data, while the estimation of the parameters is carried out in its VECM representation. Consequently, the shocks will typically have a permanent effect.

We look at four shock scenarios:

1. A +1% shock to US real output
2. A +1% shock to euro area real output
3. A +50bp shock to euro area short-term interest rate
4. A +50% increase in oil prices

For each shock we will discuss its spatial propagation through the system as well as its time dynamics with a regional focus on emerging Europe. We are interested in the long-run consequences[5] of the exogenous shocks to the real economy and therefore report the *response of real output* to the four shocks listed above. Aggregated results for the CEE, SEE and the CIS are based on purchasing power parity (PPP) weights (see the data Appendix). Since there is no coherent macro model for the region, findings based on time series and more structural models for single economies will serve as benchmark to embed our results into the literature.

[4]Orthogonalized impulse response functions in the GVAR framework have been put forward in Dees et al. (2007a). In addition to an ordering of the variables employed, they require, an ordering of the countries in the system. That is, one would have to assume a 'pecking-order' of the countries which limits the usefulness of orthogonalized impulse response functions in the context of the GVAR model per se. Recently Eickmeier and Ng (2011) have proposed the use of sign restrictions to identify structural shocks in a GVAR framework.

[5]To assess the short-run reaction of the economies to external shocks we have calculated the impact elasticities provided in Appendix C.

5.1 A Shock to U.S. Output

We start by looking at a shock to U.S. real output. A 1% shock to U.S. real output translates into a long-run response for the economy of about the same size. In parallel with economic expansion, inflation and interest rates tick up modestly, while oil prices increase more strongly (6.6%). The responses of real output of the other advanced economies are shown in Figure 1, top panel, left-hand side. Economies that are strongly integrated with the U.S. economy, such as Canada (0.8%) and the U.K. (1%), see output increase in the long-rung in the amount of almost the size of the response in the U.S. itself. The US real output shock translates into a somewhat smaller but still sizeable increase in the euro area (0.7%) and Japan (0.5%).

Figure 1, top panel on the right-hand side, shows the results for the countries in CEE. The rise in U.S. output triggers an increase in real output of 0.6% on a PPP-weighted average for the region. Looking at cross-country differences, small economies that are open to trade turn out to benefit most from the U.S.-driven global expansion. These economies include Slovenia (1.1%), Slovakia (1%), Hungary (1%) and – to a slightly lesser extent – the Czech Republic (0.8%). By contrast, the impact of the US output shock on Poland (0.3%) is more contained, which complies with the comparably smaller degree of openness of the economy and the strong resilience of Poland during the recent global financial crisis.

A similar picture arises for SEE, which responds with a permanent increase in output of 0.6% on average. With the exception of Albania, whose economy seems to be insulated from the shock, the economies respond in a similar range as do their peers from the CEE region. As before, smaller economies such as Croatia (0.8%) and Serbia (0.6%), respond in a more pronounced way. The responses of the remaining countries are very similar and are in the range of 0.4% (Turkey) and 0.6% (Bulgaria). Note that the strong reaction of economies that do not share significant trade ties with the U.S.A., might be well distilled via knock-on effects through the euro area's output rise.

The U.S. output shock translates into a 0.7% increase of real GDP in the CIS. Output in Russia rises by 0.8%, which might be partially explained by the rise in oil prices by about 7% that moves in parallel with the increase in U.S. real output. The largest response in the region can be observed for the Ukrainian economy (1%), while the remaining countries react in the range of -0.1 to 0.7%.

5.2 A Shock to Euro Area Output

The U.S. real output shock is contrasted with a shock of the same magnitude to real activity in the euro area. The increase in the euro area's real activity translates into a permanent 0.9% increase of real output. At the same time, inflation as well as short- and long-term interest rates in the euro area tick up modestly, while the real exchange rate of the euro vis-à-vis the U.S. dollar depreciates. The responses of real output are depicted in Figure 2. Real output in the U.K. closely follows that of the euro area. The responses of the U.S.A. (0.6%), Canada (0.6%) and Japan (0.4%) are slightly less pronounced, which reflects the comparably smaller degree of economic ties between these economies and the euro area.

The average response in CEE is about 0.5% in the long run. Complying with the results for

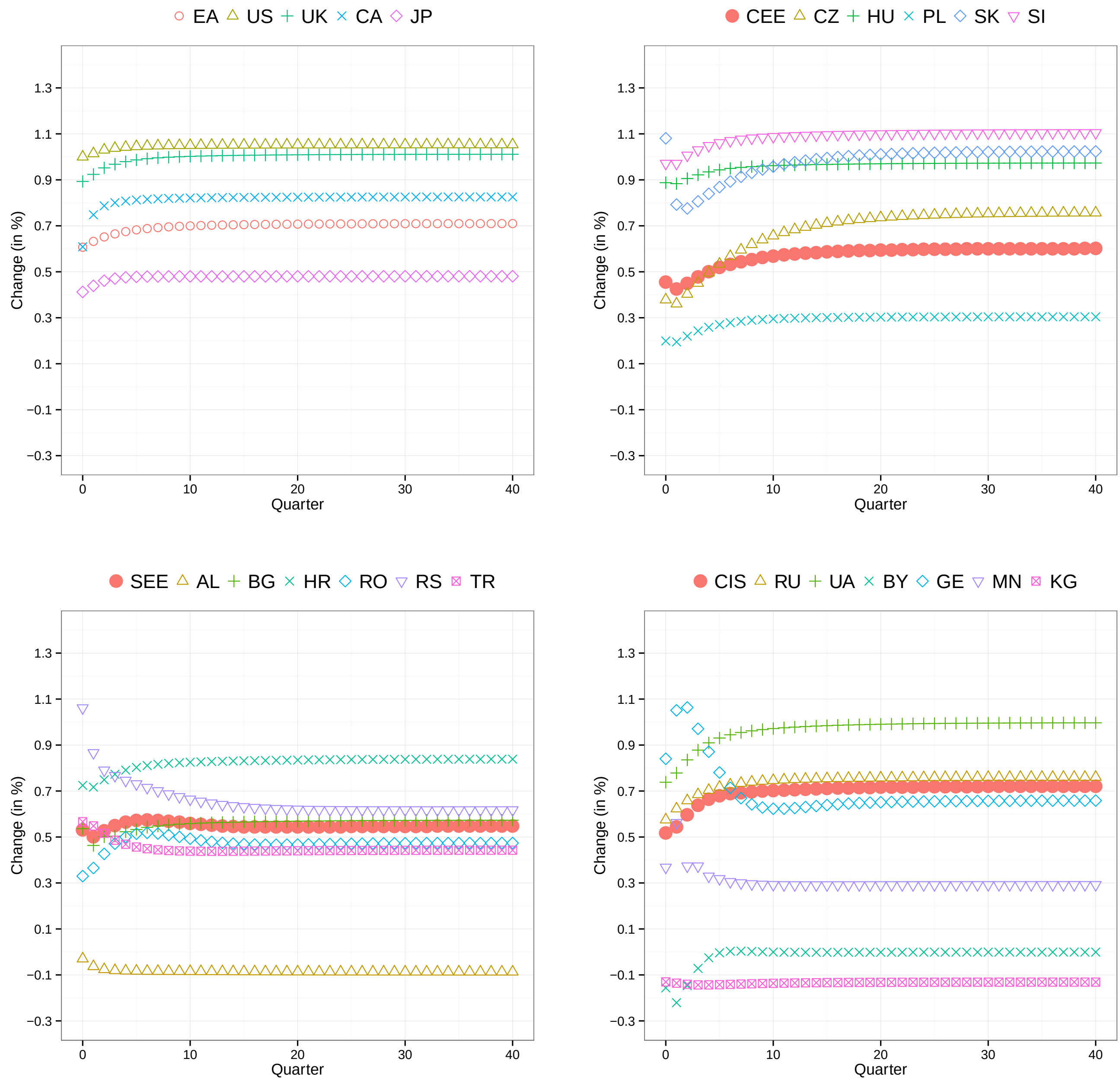

Figure 1: Response of Output to a +1% Shock to US Output. Regional aggregates are computed using purchasing power parity (PPP)-based weights. Turkey and Russia are excluded from the SEE and CIS aggregate to ease inter-regional comparison.

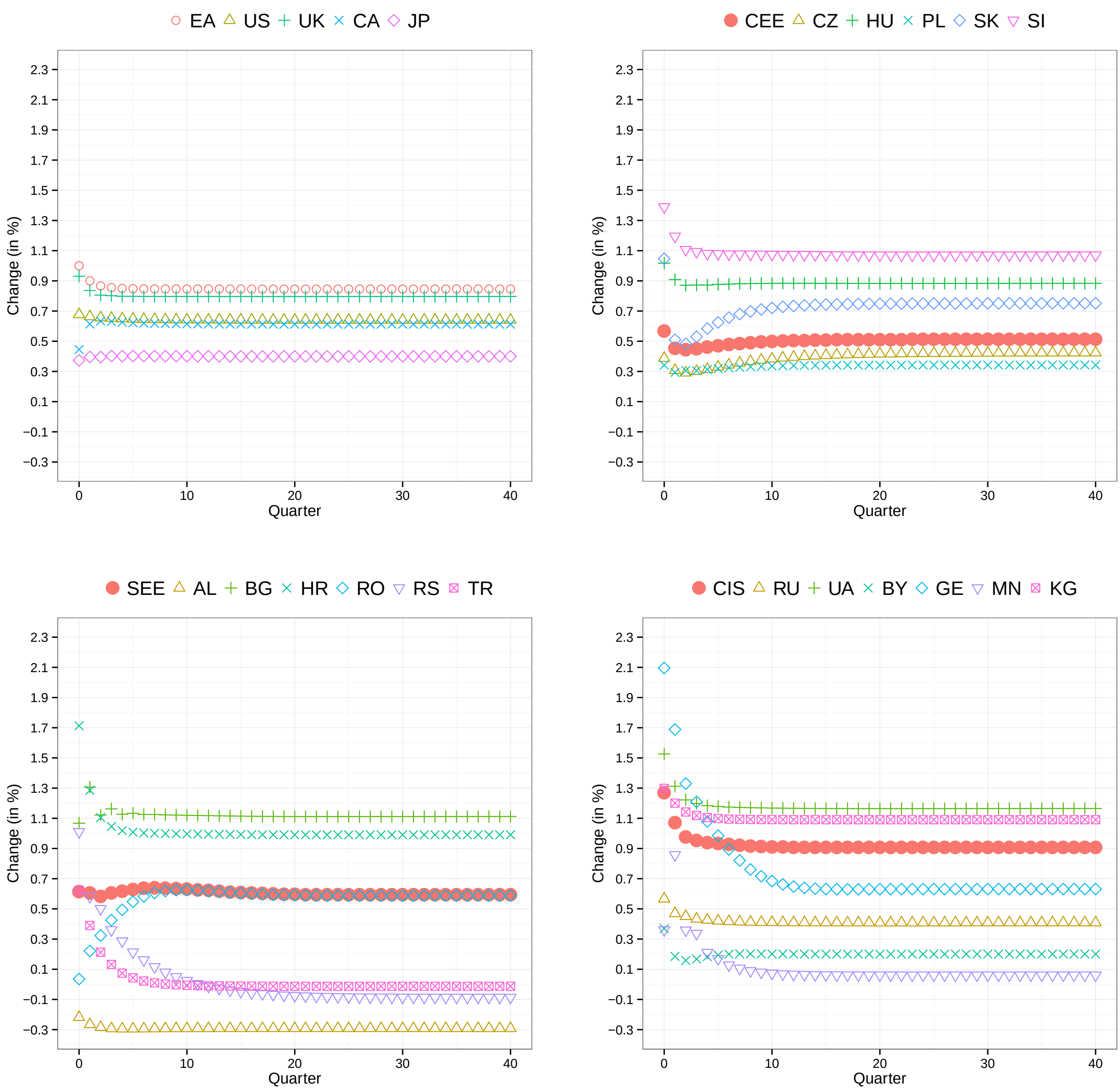

Figure 2: Response of Output to a +1% Shock to Output in the Euro Area. Regional aggregates are computed using purchasing power parity (PPP)-based weights. Turkey and Russia are excluded from the SEE and CIS aggregate to ease inter-regional comparison.

the U.S. based output shock, Slovenia (1.1%), Hungary (0.9%) and Slovakia (0.8%) show the most pronounced reactions. Similarly, the results for the Polish economy are more contained (0.3%). Note that all economies react in a very similar way to both foreign output shocks despite the larger trade ties of CEE with the euro area. The Czech Republic responds even slightly more strongly to the U.S. shock than it does to the euro area shock (0.4%). This finding is in line with Jiménez-Rodriguez et al. (2010), who find larger responses of domestic industrial production to U.S. shocks for most of the CEE economies.

SEE countries react somewhat more strongly (0.6%) than the CEE region. As with the previous shock, particularly strong reactions are recorded in Bulgaria (1.1%) and Croatia (1%). Albeit pronounced, the response of the Croatian economy is still below recent results in the literature: Krznar and Kunovac (2010) report a long-term increase of 2% in response to a shock to EU output. Surprisingly, Turkey and Serbia are rather insulated from the shock, while the response of the Albanian economy is again slightly negative. The relatively smaller response of Turkey and Serbia to an EU shock compared to their response to an U.S. shock is in line with findings provided in EBRD (2012).

The CIS economies show on average the strongest response to the euro area output shock (0.9%) compared to their peers, which nearly exceeds the long-term impact of the shock on the euro area itself. This effect, however, is to a large extent driven by a pronounced response of the Ukrainian economy (1.2%). In Russia the output shock translates into a comparably much smaller 0.4% rise in domestic real activity. The remaining countries of the CIS region show a divergent response ranging from 0.1 to 1.1% in the long run.

5.3 A Shock to Short-Term Interest Rates in the Euro Area

Next, we examine the impact of a 50 basis point increase in the euro area's short-term interest rate on the global economy. There is a considerable bulk of the literature dealing with the response of the economy to a foreign interest rate shock. A rise in interest rates in the euro area is expected to deter domestic real output which in turn might curb demand for exports from emerging Europe (Jiménez-Rodriguez et al., 2010). This effect might be partially offset by a boost to external competitiveness in emerging Europe via a depreciation of the real exchange rate. Which channel dominates remains an empirical matter and can be further examined by the GIRFs provided in Figure 3 below.

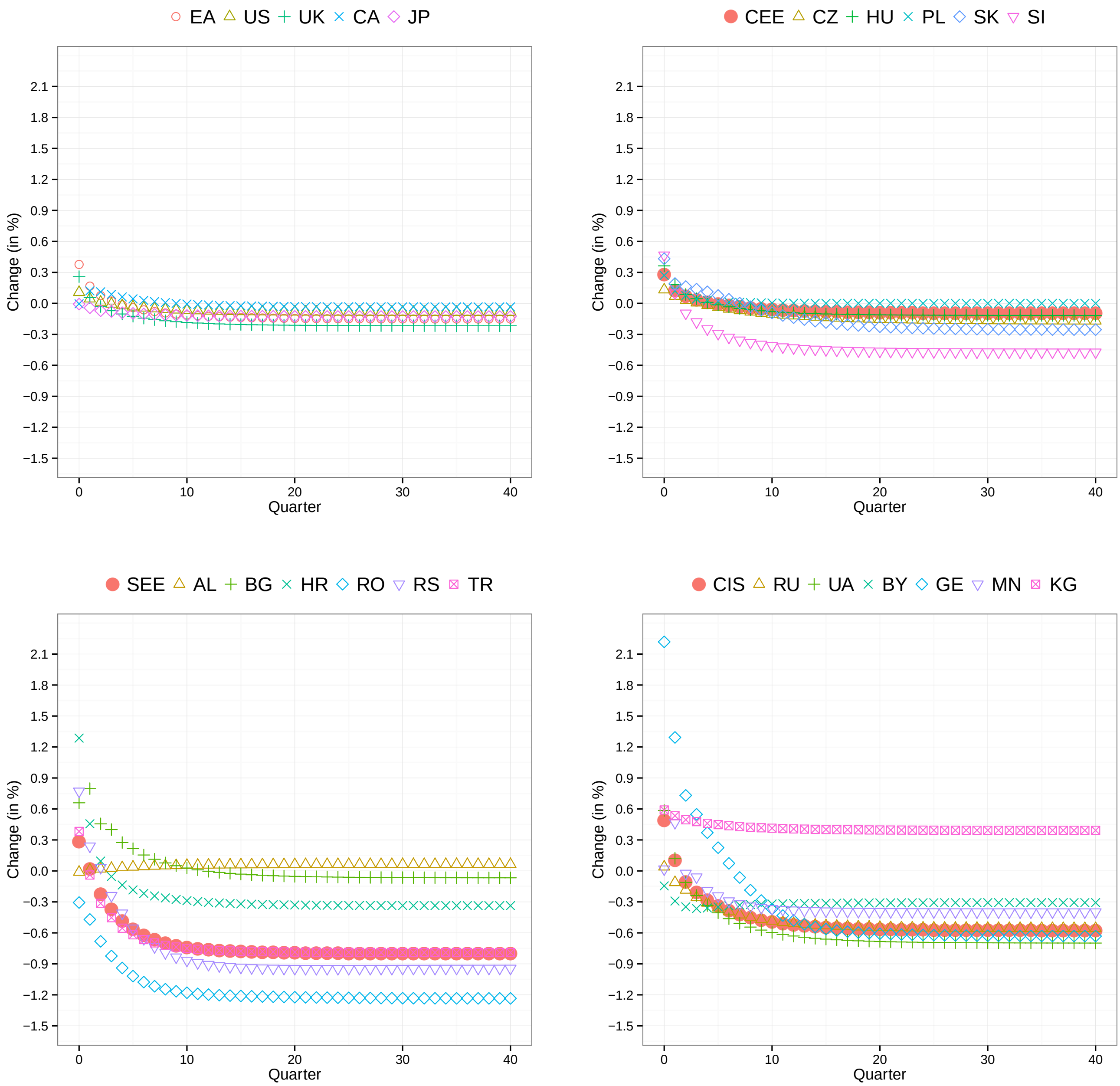

Figure 3: Response of Output to a +50bp Shock to Short-Term Interest Rates in the Euro Area. Regional aggregates are computed using purchasing power parity (PPP)-based weights. Turkey and Russia are excluded from the SEE and CIS aggregate to ease inter-regional comparison.

A 50 basis point increase in the euro area short-term interest rates translates into a 0.2% decrease in real output in the euro area and a deterioration of real output in the remaining advanced economies in the range of 0% to 0.2%. On average, countries in the CEE region show a very similar reaction compared to that of the advanced economies (-0.1%). This is partially driven by the resilience of Poland, which, in turn, is explained by the strong domestic component of economic growth compared to the other more export-oriented economies. The result for Poland might imply that the transmission mechanism of the shock operates more strongly via the export rather than the competitiveness channel. The most pronounced reactions in the region are recorded in Slovenia (-0.5%) and Slovakia (-0.3%), both being euro area member states in the most recent part of the data sample. The Czech Republic (-0.2%) and Hungary (-0.1%) also respond to the positive euro area interest rate shock with a deterioration in real output. Regarding the size of the response our results are between those reported in Jiménez-Rodriguez et al. (2010) and Benkovskis et al. (2011).

The long-run reaction for countries belonging to the SEE region is on average -0.8% and thus much stronger compared to that of the CEE economies. This might be partially explained by crisis-induced hikes in interest rates at the beginning of the sample (e.g., Bulgaria in 1998) resulting in historically large elasticities related to short-term interest rates. While we have tried to mitigate this effect by introducing country-specific dummy variables, it might still account for the response which is on average larger compared to that of the CEE economies. In this vein, the reactions for Romania (-1.2%) and Serbia (-0.9%) and Turkey (-0.8%) are still very strong. By contrast, the shock tends to be absorbed more quickly in Croatia (-0.3%) and Bulgaria (-0.1%).

The increase in euro area short-term interest rates triggers negative responses of real output also in the CIS (-0.6%). They are particularly pronounced in Ukraine (-0.7%), Georgia (-0.6%) and Russia (-0.6%), while they are in the range of -0.3% (Belarus) to +0.4% (Kyrgyz Republic) for the remaining countries.

5.4 A 50% Increase in Oil Prices

Finally, we look at the response of the global economy to a 50% hike in oil prices. We expect oil exporting countries to see their economic activity stimulated by the positive oil price shock. For emerging Europe, this holds true in particular for Russia, whose economy is largely dependent on oil price developments (see e.g., Benedictow et al., 2013). Oil importing economies are in general expected to experience a slowdown in economic activity, which moves in parallel with a rise in (imported) inflation. This effect might be partially offset for those countries that share strong trade ties with the oil exporter and can benefit via spillovers from the neighboring country.

The effect of the +50% increase in oil prices is shown in Figure 4.

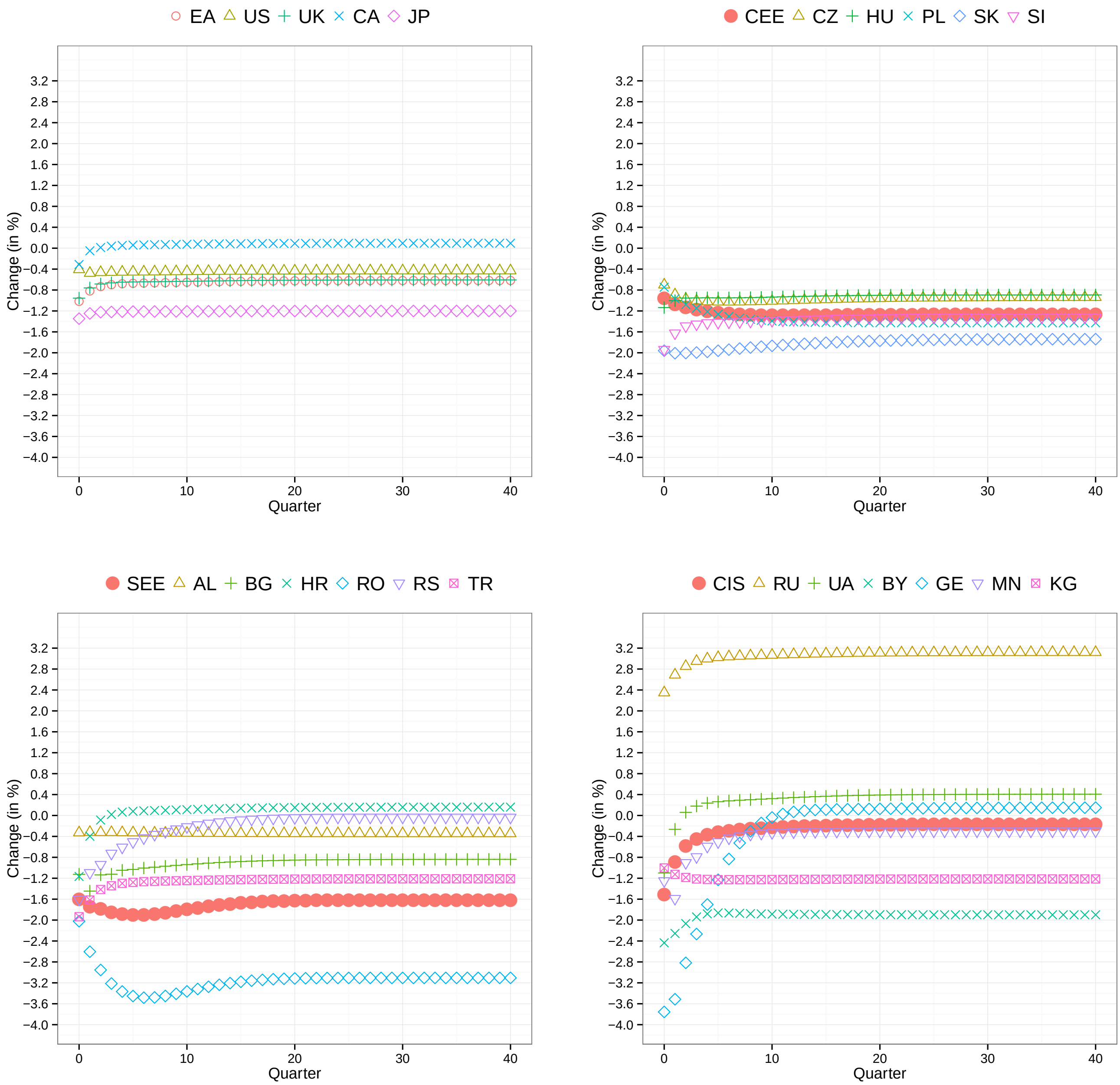

Figure 4: Response of Output to a +50% Shock to the Oil Price. Regional aggregates are computed using purchasing power parity (PPP)-based weights. Turkey and Russia are excluded from the SEE and CIS aggregate to ease inter-regional comparison.

As expected, oil importers, such as the U.S.A. (-0.4%), the euro area (-0.6%), the U.K. (-0.60%) and Japan (-1.2%), are negatively affected by the rise in oil prices. For Canada, the benefits from an oil price hike outweigh the negative repercussions of the output drag in the U.S.A. The CEE economies are all net importers of oil and are therefore expected to see their output decrease in response to the increase in oil prices. On average, the region responds with a 1.2% drag on long-term output. In line with the results of the foreign output shocks, Slovakia (-1.7%), Slovenia (-1.3%) and Hungary (-0.9%) feature among the economies that show the most pronounced reactions in the region. However, the oil price shock dampens output also in countries that have been resilient to fluctuations in foreign output so far. Poland, being insulated from both output shocks, turns out to be exposed to an oil price increase (-1.4%). In the same vein, the Czech Republic responds more strongly to the oil price hike than to previous foreign shocks. The results for the Czech economy (-0.9%) are somewhat smaller than those provided in Dybczak et al. (2008).

Compared to its peers from the CEE region, SEE reacts again slightly more strongly to the foreign shock (-1.6%). The cross-country variation, however, is more sizeable for the oil price shock. In particular, the oil price hike triggers a pronounced deterioration of the real economy in Romania (3.1%), Turkey (1.2%) and Bulgaria (0.8%) while Croatia and Albania are insulated from the shock. The resilience of the Croatian economy to the oil price shock is in line with results provided in EBRD (2012). Our results deviate, however, considerably for other countries in CEE and SEE that are flagged by EBRD (2012) as resilient to the oil price shock. The differences in results might be ascribed to the features of the GVAR model allowing for higher-order knock-on effects within the global economy.

Finally, countries in the CIS respond on average negatively to the oil price shock (-0.2%). The responses, however, show great variation. Russia, for example, as the largest oil exporter in our sample, responds with a permanent and significant increase of real output (3.1%). The size of the effect is somewhat smaller than suggested in Korhonen and Ledyaeva (2010) who use a trade linkages approach to capture economic ties between countries. Although the remaining countries in the CIS are as net importers of oil too, some countries can reap the benefits from the Russian oil price-driven expansion. This holds in particularly true for Ukraine (0.4%) and Mongolia (0.3%) and slightly so for Georgia (0.1%). In Belarus (-1.9%) and the Kyrgyz Republic (-1.2%) positive spillovers from Russia cannot offset the drag on the economy brought about by the increase in oil prices.

5.5 Generalized Forecast Error Variance Decomposition

The forecast error variance decomposition facilitates interpretation of the forces that are at work in a dynamic time series model. In general, it resembles the amount of information that each variable contributes to explaining the remaining variables in the system. The forecast error decompositions can be used to either assess the relative importance of the variables within a country model or to highlight the importance of foreign versus domestic factors in explaining the forecast error variance. It is typically performed based on the orthogonalized variance covariance matrix. For reasons explained in the previous section we rely on the generalized impulse response functions instead. Its counterpart, the generalized forecast error variance decomposition, is conditioned on the set of non-orthogonalized shocks and allows for contemporaneous correlation between the shocks and the shocks of other equations (Dees et al., 2007b). It is given by:

$$\text{GFEVD}(y_t, u_t, n) = \frac{\sigma_{jj}^{-1} \sum_{l=0}^{n} (s_l' F_l G^{-1} \Sigma_u s_j)^2}{\sum_{l=0}^{n} s_l' F_l G^{-1} \Sigma_u (G^{-1})' F_l' s_l} \tag{7}$$

with σ_{jj} denoting the jjth element of the variance covariance matrix Σ_u and n the forecast horizon. Due to the (typically positive) contemporaneous correlation among innovations the proportions are often larger than unity (Dees et al., 2007b; Bussière et al., 2009; Galesi and Lombardi, 2009). The results are illustrated in Table A7 in the Appendix. The top panel of the Table shows the fraction of the forecast error per variable averaged across the countries.

We start with investigating the shock to U.S. real output. Naturally, the corresponding forecast error variance is largely explained by real output across countries (5.2), while also short- and long-term interest rates contribute strongly (1.5). As the forecast horizon expands, and through the lag structure in the system, the contributions of the remaining variables increase. However, after 40 quarters the average share of real output variables in explaining the variance of the historical shock is still about 2.5 to 3.5 as large as the one of the remaining variables. Similar to the U.S. shock, the euro area real output shock (shock 2, Table A7) can be to a large part explained by output in the system. However, compared to the shock emanating from the U.S.A., the distribution of average shares among variables is more balanced. In the long run, variation in real output variables contribute on average by about the same magnitude as inflation variables and about twice as much as the remaining variables. Taken at face value, this implies a stronger link of global output with U.S. output than with economic activity in the euro area.

Columns 7 to 9, top panel in Table A7 illustrate the contributions of the variables employed in the system to the 50 basis point increase in short-term interest rates. On impact, about the same fraction of the historical shock is explained by inflation variables, real output and short-term interest rates, which is indicative for strong monetary policy links in the system and hence corroborating findings put forward in Maćkowiak (2006). In the long run, inflation variables contribute most strongly (5.1), followed by real output (3.4) and to a lesser degree the real exchange rate and long-term interest rates (1.8). The last set of columns illustrates the forecast error variance decomposition for the 50% oil price shock. Inflation variables can explain the largest share of forecast error variance associated to the shock. This seems plausible since movements in the oil price are often associated with global supply and demand conditions and their link to inflation is well documented in the literature (e.g., Jiménez-Rodriguez et al., 2010). Looking at the time profile, the relative importance of national price dynamics decreases in the long-run, while that of real GDP and short-term interest rates increases.

The bottom of Table A7 contains the average fraction of the forecast error explained by variables per country. This should provide insights about regional differences in shaping the variables under scrutiny. Quite naturally, the largest share of forecast error variance of the U.S. output shock is explained by U.S. variables (15.5) on impact. Also in the long run, U.S. variables (12.4) contribute most strongly, followed by the variables of other advanced economies such as the euro area (6.2), UK (4.2) and Japan (3.6). Emerging Europe can explain the forecast error variance to a lesser degree (0.6 to 2.9). Note that Hungary seems to be an exception to this. The forecast error variance decompositions for the +1% shock to real output in the euro area are depicted in columns 4 to 6, bottom panel in Table A7. Similar to the U.S. shock, advanced economies explain a significant share of the forecast error variance, which could be taken as further evidence for the high degree of synchronization among advanced economies' business cycles. However, and in contrast to the U.S. shock, some countries in emerging Europe – most notably Russia – contribute to a similar degree as do advanced economies.

The average shares of explained variation related to the shock to short-term interest rates in the euro area are depicted in columns 7 to 9 in Table A7. In the long run, variance of the historical shock is most strongly explained by euro area variables. With the exception of Serbia, the contributions of countries in emerging Europe lie in the range of 0.8 to 5 and are thus comparable to those of advanced economies. This result complies with findings by Maćkowiak (2006) who demonstrates the importance of an interest rate shock for the region. The last set of columns depicts the regional distribution of explained error variance associated to the 50% oil price shock. In the long run, the forecast error variance can be explained most strongly by U.S. variables followed by the variation observed for oil exporting countries and the euro area. More specifically, U.S. variables contribute about twice as much as the euro area, Canada and Russia.

6 Conclusions

In this paper we put forward a global VAR model for emerging Europe. We analyze the response of the region to four different external shock scenarios with a focus on the consequences for the real economy. The broad range of external shocks covers two positive shocks to foreign output, an increase in the euro area's short-term interest rate and a rise in the oil price. The scenarios are analyzed by means of generalized impulse responses and a forecast error variance decomposition. This allows us to draw a coherent picture of how shocks are transmitted to the real economy of the region and to quantify their impact on these economies.

Our *general* findings are as follows: First, in line with our expectations, small open economies tend to be more vulnerable to foreign shocks. More specifically, Slovenia, Slovakia, Croatia and Ukraine are among the most exposed countries to all four shock scenarios investigated in this paper. That is, compared to their peers from the region, these economies tend to be more dependent on the euro area and the U.S. economies. Second, emerging Europe reacts to an output shock emanating from the U.S. by and large to the same extent compared to a corresponding euro area output shock. At first sight, this might be a surprising finding given the region's high degree of trade integration with the euro area. However, the U.S. still plays a pivotal role in the world economy despite the rise of fast-growing emerging economies like China (Feldkircher and Korhonen, 2014). This result is also confirmed by the forecast error variance decomposition that shows a strong link of real activity across the globe and the U.S. economy. Consequently, the U.S. output shock might be interpreted as a global output shock. Furthermore, emerging Europe does not only benefit directly from U.S. economic growth. In addition, knock-on effects from the euro area may contribute to passing the effects of the U.S. economic expansion on to emerging Europe. The strong reaction of emerging Europe to the U.S. output shock is also demonstrated in Jiménez-Rodriguez et al. (2010) and – if the U.S. is given a global interpretation – in EBRD (2012). Last, the forecast error variance decomposition reveals a notable link of foreign interest rates for the region (see also Maćkowiak, 2006). This is further corroborated by the pronounced reaction of the real economy – most notably in the CIS and SEE region – shown by the respective impulse response functions. The strong role of the foreign interest rate shock might be partially driven by the fact that some of the countries peg their currencies in one way or the other to the euro.

Looking at the *regional differences* in the responses to the four shock scenarios the following picture emerges: While *advanced economies* react positively to both the U.S. as well as the euro area output shocks, responses to the U.S. shock tend to be more pronounced. The euro area interest rate shock dampens real output in all advanced economies. That is, advanced economies show a strong degree of co-movement in reactions to external shocks in output and short-term interest rates. Furthermore, advanced economies react negatively to a hike in oil prices, with only Canada – one of the biggest oil exporters in our sample – responding with an increase in real output. In other words, in Canada gains from an increase in the oil price seem to offset negative spillovers from the drag on the U.S. economy. In general, the shapes of the reactions among advanced economies are very homogeneous. Consequently, according to our results advanced economies seem to be strongly integrated with the global economy. This is also evident from the forecast error variance decomposition according to which variation in variables of advanced economies can be explained to a higher degree by the U.S. and the euro area shocks compared to variation in emerging economies.

The region of *Central Eastern Europe* shows a more diverse pattern. Compared to their peers in the region, Slovenia, Slovakia and Hungary react most strongly to both output shocks. Interestingly, Slovakia shows an even more pronounced reaction to the U.S. expansion compared to the shock emanating from the euro area. However, the Slovak economy (exporting sector) relies particularly strongly on industries (e.g., cars and electronics) that proved rather resilient to economic downturns in the euro area (EBRD, 2012). Viewed from this angle, the Slovak economy seems to be more dependent on fluctuations in the global economy rather than on those in the euro area. On top of this, and in line with our expectations, Slovenia and Slovakia show the most pronounced response to the euro area interest rate increase. Before adopting the euro (representing the most recent period of our data sample), both countries pursued a monetary policy regime that was strongly linked to the euro area. The response to the increase in oil prices is negative throughout the region, which can be ascribed to the fact that all countries are net importers of oil. Poland's reaction to all foreign shocks but the oil price shock is exceptional compared with the responses of its peers in the region. The response to both output shocks is comparably small but still positive, and the economy is completely resilient to the increase in the euro area's short-term interest rate.

In line with the results established so far, the response of *Southeastern Europe economies* to the output shocks is mostly positive. The responses to the output shock emanating from the U.S.A., however, are much more clustered around the region's average response. By contrast, country specifics play a larger role for the responses to the euro area shock. Pronounced reactions to both output shocks, in particular to the one emanating from the euro area, are recorded in Croatia and Bulgaria. In this vein we corroborate findings provided in Krznar and Kunovac (2010), who empirically find an extraordinarily strong dependence of the Croatian economy on foreign output shock emanating from the EU. Turkey, the biggest economy in the region, is more exposed to foreign output shocks from the U.S.A., while it is strikingly resilient to a corresponding euro area output shock. The same pattern can be observed for Serbia. Both results corroborate findings provided in EBRD (2012). According to our results, the Turkish economy is also very vulnerable to an increase in the oil price, which complies with the fact that the country is a large net importer of oil. In the same vein, the response of the other economies is negative to the oil price hike, with only Croatia being relatively insulated from the shock. Romania's response to both output shocks is well in line with the region's average. However, compared to its peers the economy is among the most affected ones in response to the oil price and the euro area interest rate shock. The strong reaction of the Romanian economy to a foreign interest rate shock is also found in Caraiani (2008) who employs a structural DSGE model to assess the economy's reaction to domestic and foreign shocks.

Finally, we summarize the results for the countries of the *Commonwealth of Independent States*. Our results for the Russian economy corroborate findings in the literature that report a strong dependence of the economy on oil price developments (see e.g., Rautava, 2004; Ito, 2008; Korhonen and Ledyaeva, 2010). The GVAR model predicts a long-run increase in real output in the magnitude of close to 3% in response to a 50% increase in the oil price, which is a smaller impact than the one found by Korhonen and Ledyaeva (2010). However, our model is capable of taking into account negative second-round effects from Russia's trading partners, whose output is dampened by the oil price increase. We furthermore find a strong reaction of Russian output to a positive output shock in the U.S.A. This finding is driven by the strong economic ties these countries share with each other on the one hand and by the increase in the oil price as a result of the U.S. expansion on the other hand. The Russian economy shows also a strong negative reaction to the increase in the euro-area's short-term interest rate, which might be partially attributed to the Russian exchange rate regime that is anchored to the euro and the U.S. dollar in nearly equal terms. Our results furthermore reveal Ukraine as one of the economies most vulnerable to all sorts of foreign shocks (EBRD, 2012). More specifically, the economy reacts strongly to the U.S. output shock and in an even slightly more pronounced way to the corresponding euro area output shock. Our findings furthermore corroborate the importance of Russian knock-on effects for the CIS and in particular for the Ukrainian economy. In this vein, second-round effects from the oil price-driven Russian expansion seem to offset the drag on output in Ukraine brought about by the increase in oil prices.

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A Data

Data on *real GDP* are indexed so that the average of quarterly real GDP in 2005 equals 100. The majority of data are from the IMF's IFS data base. Data for Albania, Russia and Ukraine are based on national sources. Real GDP for China is based on a series provided by the Bank of Finland Institute for Economies in Transition (BOFIT). The series have been transformed in logarithms and seasonally adjusted. Seasonal adjustment has been carried out using iteratively local smoothing regressions (Cleveland et al., 1992) to isolate the sub-components of the time series. Real GDP for the euro area (1995Q1-1997Q4), Indonesia (1995Q1-1996Q4), India (1995Q1-1996Q3), Romania (1995Q1-1997Q4), Albania (1995Q1-2004Q4), Republic of Serbia (1998Q1-2000Q4),Georgia (1995Q1-1995Q4), Kyrgyz Republic (1995Q1-1999Q4), Mongolia (1995Q1-1999Q4), Ukraine (1995Q1-2000Q4) Iceland (1995Q1-1996Q4) has been extrapolated using annual growth rates of GDP (IMF, IFS database).

Consumer price *inflation* is calculated as $Dp_t = log(p_t) - log(p_{t-1})$ with p denoting the CPI. Complying with the data on real output, the index is normalized such that the average of the four quarters in 2005 is 100. The majority of data on the CPI are from the IMF's, IFS database. CPI for the Chinese economy is from Thomson Reuters. Seasonal adjustment was carried out as described above. Missing values for the euro area (1995Q1-1997Q4) have been interpolated using data on annual inflation rates (IMF, IFS database).

Data on *short-term interest rates* typically refer to money market rates. Other proxies are used for Albania (deposit rate), Australia (average rate on money market), Bulgaria (interbank rate), Belarus (deposit rate), Canada (overnight money market rate), China (deposit rate), Denmark (call money rate), euro area (interbank rate, 3-month maturity), Georgia (deposit rate), Hungary (treasury bill), Indonesia (call money rate), India (call money rate), Japan (call money rate), Mongolia (deposit rate), Mexico (bankers' acceptances), Malaysia (interbank overnight money), Norway (deposit rate), Peru (interbank rate), Sweden (call money rate), Singapore (3 month interbank rate), Turkey (interbank money market rate), United Kingdom (overnight interbank rate), U.S.A. (federal funds rate). All data are from the IMF's, IFS database.

Data on *Long-term interest rates* corresponds to government bond yields with 5 to 15 years maturity. All data are taken from the IMF's, IFS database and from the OECD (Chile, Mexico and Russia). *Oil prices* are measured in U.S. dollar per barrel and are taken from the IMF's IFS database. Oil prices are seasonally adjusted and in logarithms. We use the average *nominal exchange rates* vis-à-vis the U.S. dollar per quarter from the IMF's IFS database. The time series is in logarithms. Real exchange rates are then calculated by subtracting the seasonally adjusted, national consumer price level (p_t). We use bilateral *trade flows* on an annual basis. The trade flows are measured in U.S. dollar and comprise exports (FOB) and imports (CIF) of goods. Data is from the IMF's direction of trade data base. To construct regional impulse responses we use purchasing power parity (PPP) converted GDP based on the Penn World Table's 7.0 vintage (`http://pwt.econ.upenn.edu/php_site/pwt70/pwt70_form.php`, download code: tcgdp). In particular, we use an average over the period from 2000-2006 of PPP converted GDP. All data for the euro area are taken from the IMF's IFS data base. Note that these series are calculated on a rolling basis. That is, the series is always based on the current set of member countries. While it would be possible to calculate a PPP-weighted average for prices and real output for the euro area member states but Slovakia and Slovenia, this is cumbersome for interest rates and exchange rates. Note that only a relatively small number of observations in the euro area series are based on data from these countries, since they joined monetary union in 2009, 2008 and 2007 respectively. As a robustness check we have calculated real output and inflation based on a PPP-weighted average of the remaining countries. Our results are available on request and do not change qualitatively. For consistency reasons we opt for real output and prices also for the euro area series.

For some emerging markets historical data were incomplete. Missing data have been imputed by using a bootstrap based multiple imputation algorithm fully described in Honaker and King (2010). We have taken 10 imputations and calculated the average to impute missing values. There is only one country with missing data on real output: Serbia (1995Q1-1997Q4). Most missing values had to be imputed for short- and long-term interest rates. Note that we only impute historical values and up to a maximum of 12 observations. For countries that share a variable with more than 12 missing values, the corresponding variable is dropped from the country model. Short-term interest rates have been imputed for the following countries: Kyrgyz Republic (1995Q1-1997Q1), Ukraine (1995Q1-1996Q3), Georgia (1995Q1-1995Q2), Peru (1995Q1-1995Q3), Egypt (1995Q1-1996Q4) and Slovakia (1995Q1-1995Q2). Long-term interest rates have been imputed for Bulgaria (1996Q3-1997Q1) and Iceland (2008Q1-2008Q2) only.

B Model Specification

We have tested for the number of cointegration relationships in each country model. As in Pesaran et al. (2004) we employ a nested Likelihood-Ratio (LR) test that is based on the eigenvalues derived from the reduced rank regressions of the country VECMs. The results for the LR based on the trace statistic are summarized in Table A8. The test identifies for most of the countries 2-3 relationships that determine the long-run behavior of the economy.

In the next step the deterministic components are then tested for by means of a Likelihood ratio test. Following Juselius (2006), we distinguish five cases:

- Case I: is a zero intercept, zero trend model.
- Case II: is a restricted intercept, zero trend model.
- Case III: is an unrestricted intercept, zero trend model.
- Case IV: is an unrestricted intercept restricted trend model.
- Case V: is an unrestricted intercept, unrestricted trend model.

Deterministic components are estimated as component of Π in equation 1. In other words, they are restricted to lie in the cointegration space. Note that Case V would imply a quadratic trend in levels, which seems implausible for macroeconomic data. The test results are provided in Table A9. According to the test, we specify the deterministic components of 24 out of the 43 country models with an unrestricted intercept term and a trend component that is restricted to lie in the cointegration space (Case IV). While this is by far the most common specification in applied work, the fact that our sample includes the period of the global financial crisis renders the specification test a priori necessary. Indeed, there are some countries for which the empirical test points to other specifications (Case I, 6 countries, Case II 8 countries, Case III 5 countries and 6 countries Case V). We have ruled out Case V and set the specification for these countries to Case IV.

Conditional on the specifications above we proceed with examining the long-run properties of the system in more detail. This proves useful since we are ultimately interested in the response of the system to various exogenous shocks.

By means of the so-called persistence profiles (PP) we can assess how the long-run relationships react to small perturbations:

$$\mathrm{PP}(\beta_{ji}' z_{it}, u_t, n) = \frac{\beta_{ji} \mathcal{W}^i F_n G^{-1} \Sigma_u s_j}{\sqrt{\sigma_{jj}}} \tag{8}$$

with F_n denoting the dynamic multiplier matrix $F_n = \sum_{n=1}^{n} F_{n-1} (\sum_{i=1}^{max(p_i,q_i)} G^{-1} H_i)$ and n the forecast horizon. The shape and time profile of the PPs are indicative of the persistence of a shock to the long-run equilibrium. Following Cesa-Bianchi et al. (2012) we reduce the cointegration rank for each country until the persistence profile reverts to 0 within 10 to 15 quarters. This ensures the overall stability of the model and reduces the risk of overestimation of the number of cointegration relationships based on asymptotic values.

We have finally included dummy variables for outlying observations and their corresponding interaction term with the short-term interest rate series for the following countries: in the Czech Republic (1997Q1-1997Q2), in Slovenia (1995Q1-1996Q4), in Bulgaria (1995Q1-1997Q2), in Romania (1996Q4-1997Q3, 1998Q1 and 1998Q4-1999Q2), in Croatia (1995Q1-1996Q2), in Albania (1997Q1-1998Q3), in Ukraine (1998Q3-1999Q4), in Belarus (1995Q1-1995Q2), in Georgia (1995Q1-1996Q4), in Mongolia (1995Q1-1998Q1), in the Kyrgyz Republic (1998Q4), in Argentina (2001Q4-2002Q3), in Brazil (1995Q1-1995Q4), in Indonesia (1997Q3-199Q2), in Thailand (1997Q3-1998Q2), in Korea (1997Q4-1998Q2) and in Turkey (2000Q4-2001Q1). For the following countries we have included a dummy variable and their interaction with the real exchange rate: in Malaysia (1995Q1-1997Q4), in Serbia (1998Q4-2001Q1), in Argentina (2001Q4-2002Q3), in Indonesia (1995Q1-1997Q4) and in Thailand (1995Q1-1998Q3). For Peru we have included an impulse dummy for 1998Q3.

C Impact Elasticities

Impact elasticities can be computed to indicate how the economies contemporaneously react to foreign shocks in the short run (see equation 1a). This information provides us with a hunch about how domestic variables immediately react to shocks in its foreign counterparts. More specifically, we examine the coefficients attached to foreign output in the equations of real output. To assess whether there are regional disparities, we present the results by means of boxplots in Figure A1. The results for the remaining foreign variables are provided in Table A10[6].

The figure illustrates the regional distribution of the impact elasticity with respect to foreign output. The most sizeable elasticities (> 1) are reported for Ukraine, Singapore and Serbia. Accordingly, for these countries a 1% change in foreign output in a given quarter is associated with a > 1 change in domestic real output in the same quarter. The impact elasticities in the CEE region are in particular strong for Slovenia (1.6%), Slovakia (1.2%) and Hungary (0.9%), while they are more muted in Poland (0.3%). The median of the distribution for countries in the SEE region is about the same size as for the CEE countries. More specifically, a 1% increase in foreign real output is associated with a 1.7% increase in real output in the same quarter in Serbia, 1.1% in Croatia and Bulgaria and 0.7% in Romania. In the CIS, the median of the distribution is about half of the size as for the CEE and SEE region. Pronounced elasticities are recorded for Ukraine (2.3%), as well as the Russian economy (1%). For the advanced economies the median is about 0.8%. Compared to other emerging economies, we note that the short-run response of domestic output to foreign output is more contained in Latin America and Asia (about 0.5%).

[6] Note that we have taken logarithms only for trending variables. The elasticities for interest rates provided in Table A10 thus constitute semi-elasticities.

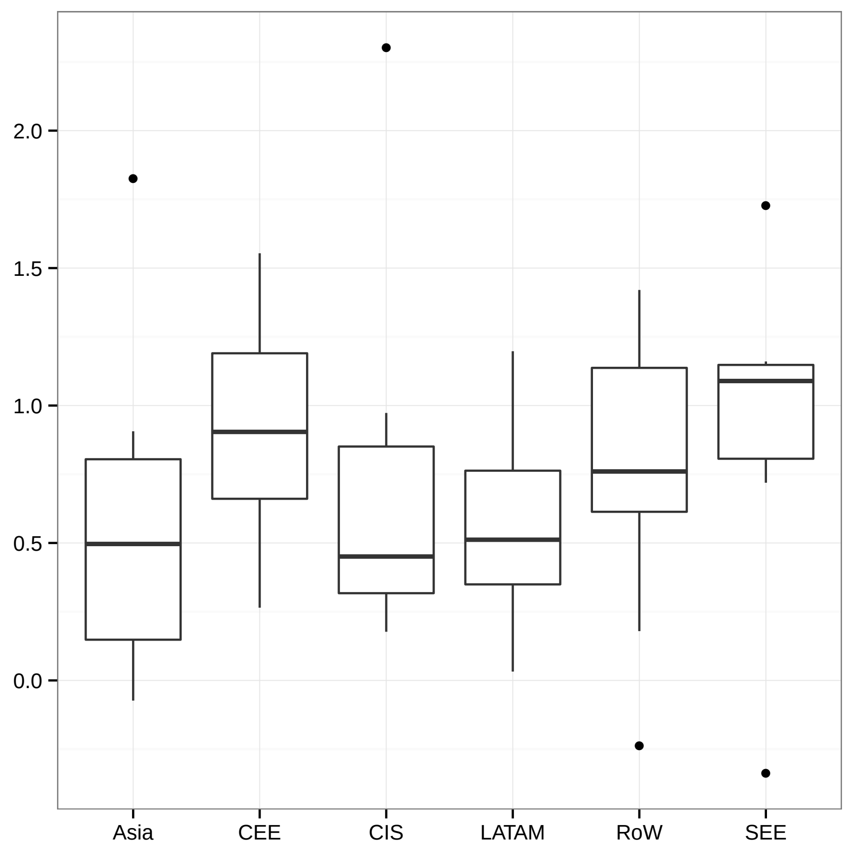

Figure A1: Short-run dynamics. Regional distribution of the coefficients attached to foreign demand in the cross-country equations for real output. The plot whiskers extend to the most extreme data point which does not exceed 1.5 times the interquartile range from the box. Values above (in absolute terms) denoted as outliers.

D Tables and Figures

	EA	US	UK	JP	CN	CZ	HU	PL	SI	SK	BG	RO	HR	AL	RS	Nr. > CV
y	-0.847	-1.215	0.370	-1.606	-1.918	-2.249	-0.163	-2.168	0.647	-1.653	-1.901	-2.716	-0.022	-2.265	-1.409	0
Dp	**-3.078**	-2.874	-0.841	**-3.119**	**-3.213**	-2.725	**-3.121**	-2.835	-1.836	-2.029	-2.415	-1.565	**-3.015**	**-3.314**	-2.656	6
rer	-2.152	-	-2.093	-1.750	-0.690	-1.993	-1.827	-1.999	-2.049	-2.101	-2.716	-1.897	-1.941	-1.725	-2.425	0
stir	-1.344	-1.462	-1.035	-2.360	**-5.082**	-1.469	**-2.930**	-1.339	-2.830	-1.176	-2.011	-0.994	**-5.047**	-2.002	-	3
ltir	**-3.119**	-0.301	-1.561	**-2.998**	-	-	-	-	-	-	**-3.466**	-	-	-	-	3
y*	-2.237	-2.713	-1.813	-1.891	-1.834	-1.485	-1.651	-1.149	-1.088	-1.121	-1.191	-1.266	-1.442	-2.485	-1.220	0
stir*	-1.611	-1.882	-1.605	-1.734	-2.181	-1.698	-2.576	-2.299	-1.955	**-3.082**	-2.439	-2.429	-2.321	-1.830	-1.524	1
ltir*	-1.520	**-4.487**	-2.745	-2.005	-1.942	**-3.043**	**-3.086**	**-2.985**	**-3.037**	**-3.068**	**-3.078**	**-3.102**	**-3.028**	**-3.308**	**-3.388**	11
	RU	UA	BY	GE	MN	KG	AR	BR	CL	MX	PE	KR	PH	SG	TH	Nr. > CV
y	-1.958	-1.293	-1.655	-1.992	-1.284	-2.554	-1.334	-1.004	-1.898	-1.715	-0.602	-2.054	-1.637	-1.586	-1.703	0
Dp	-2.468	**-3.608**	-1.196	**-4.300**	**-3.076**	-2.841	-2.116	**-2.926**	-2.794	**-3.754**	-2.764	**-3.126**	**-3.238**	-2.109	-2.779	7
rer	-2.429	-2.620	-2.324	-2.002	-1.444	-2.008	-1.516	-1.152	-1.339	-2.379	-0.959	-2.587	-1.383	-1.012	-2.104	0
stir	**-3.519**	-2.186	-1.950	**-4.626**	**-4.227**	-2.173	**-3.084**	-2.650	-	-2.205	-1.354	-1.386	-1.124	-1.474	-1.788	4
ltir	-	-	-	-	-	-	-	-	-	**-4.028**	-	-1.354	-	-	-1.571	1
y*	-1.682	-1.663	-1.668	-1.804	-1.999	-1.401	-1.184	-2.014	-1.043	-1.693	-2.808	-1.586	-2.502	-2.127	-1.978	0
stir*	-1.980	**-3.108**	**-3.307**	-2.718	**-3.605**	**-3.323**	-2.268	-2.130	-1.766	-1.257	-1.471	-1.919	-1.332	-2.028	-1.536	4
ltir*	**-2.925**	**-3.322**	**-2.912**	**-4.792**	-1.339	-2.344	-2.663	-2.505	-2.677	-0.530	-2.418	-2.017	-1.503	-1.977	-1.681	4
	IN	ID	MY	AU	NZ	TR	EG	CA	CH	NO	SE	DK	IS			Nr. > CV
y	-1.634	-1.836	-2.212	-0.079	1.001	-1.660	-1.534	-0.947	-2.045	-1.389	-1.444	-1.246	-0.877	-	-	0
Dp	-2.141	-2.402	**-3.099**	-2.705	**-3.198**	-1.068	-1.369	**-3.346**	**-3.065**	**-4.371**	-2.769	**-3.496**	-1.676	-	-	6
rer	-1.461	-2.769	-2.059	-1.771	-2.107	-2.074	-1.346	-1.982	-2.462	-2.095	-2.092	-2.235	-2.422	-	-	0
stir	**-4.429**	-2.687	-2.164	**-2.919**	-1.355	-1.027	-	-1.785	-2.489	-2.118	-2.743	-1.716	-2.531	-	-	2
ltir	-	-	-1.209	**-3.123**	-1.234	-	-	-1.401	-0.883	-0.755	-2.266	-1.557	-1.789	-	-	1
y*	-2.465	-1.904	-1.828	-1.517	-2.479	-2.111	-2.538	-1.766	-1.191	-0.959	-1.046	-1.126	-1.005	-	-	0
stir*	-2.171	-1.877	-1.542	-1.624	-2.023	-2.692	-1.744	-1.421	-1.457	-1.563	-1.389	-1.793	-1.846	-	-	0
ltir*	-2.294	-2.308	-1.812	-1.946	-2.462	**-2.971**	-2.671	-0.811	**-2.998**	-2.575	-2.446	-2.644	-2.423	-	-	2
poil*	-2.389	-	-	-	-	-	-	-2.389	-	-2.389	-	-	-	-	-	0

Table A1: ADF tests on variables in levels. The regressions for all variables except interest rates and inflation together with its foreign counterparts, contain a constant and a trend term. ADF tests for interest rates and inflation are based on a constant in the ADF regression only. The 5% critical value of the ADF statistic including trend and intercept is -3.47, the one without trend is -2.91. Significant t-statistics are in bold.

	EA	US	UK	JP	CN	CZ	HU	PL	SI	SK	BG	RO	HR	AL	RS	Nr. > CV
y	-2.395	-2.237	-1.800	**-4.060**	-2.434	-2.152	-2.116	**-4.113**	-2.000	**-3.515**	**-3.173**	-2.423	-2.242	**-4.047**	**-4.526**	6
Dp	**-5.774**	**-6.152**	**-7.209**	**-6.435**	**-4.304**	**-6.663**	**-4.751**	**-5.115**	**-6.047**	**-6.829**	**-5.320**	**-4.911**	**-5.659**	**-4.167**	**-4.542**	15
rer	-2.876	-	**-3.138**	-2.704	-2.186	**-3.504**	**-3.096**	**-3.919**	**-2.919**	-2.403	**-4.272**	**-3.636**	-2.763	**-3.599**	**-4.415**	9
stir	**-3.476**	**-3.419**	**-3.856**	**-3.719**	-2.822	-2.846	**-4.045**	**-4.458**	**-4.130**	**-3.455**	**-4.871**	**-4.258**	**-4.309**	**-4.367**	-	12
ltir	**-3.017**	**-3.708**	**-3.248**	**-4.100**	-	-	-	-	-	-	-3.341	-	-	-	-	5
y*	**-3.739**	**-4.054**	**-3.080**	**-4.443**	**-3.408**	**-3.226**	**-3.366**	-2.702	-2.783	**-3.203**	**-3.438**	**-3.133**	**-3.146**	**-3.485**	**-3.415**	13
stir*	**-4.466**	**-4.625**	**-4.071**	**-4.633**	**-3.755**	**-4.323**	**-4.053**	**-4.326**	**-4.094**	**-4.504**	**-4.809**	**-4.814**	**-4.023**	**-4.285**	**-5.144**	15
ltir*	**-3.428**	-2.569	**-3.332**	**-4.237**	**-4.735**	**-3.021**	**-3.058**	**-3.159**	**-3.042**	**-2.943**	**-3.154**	-2.797	**-3.031**	-1.858	**-7.552**	12
	RU	UA	BY	GE	MN	KG	AR	BR	CL	MX	PE	KR	PH	SG	TH	Nr. > CV
y	**-2.946**	-2.529	**-4.110**	**-3.615**	-2.494	**-4.339**	-2.329	**-3.471**	**-3.442**	**-3.018**	**-2.944**	**-4.032**	**-4.479**	**-3.922**	-2.280	11
Dp	**-5.049**	**-5.283**	**-4.485**	**-5.415**	**-4.430**	**-5.478**	**-4.718**	**-4.648**	**-5.191**	**-5.651**	**-5.361**	**-5.887**	**-5.629**	**-5.990**	**-6.518**	15
rer	**-3.475**	**-3.404**	**-3.529**	**-3.997**	**-4.922**	**-3.677**	**-3.484**	**-3.083**	**-3.683**	**-3.492**	-2.848	**-3.601**	**-3.717**	-2.804	**-3.684**	13
stir	**-4.846**	**-3.837**	**-4.300**	**-5.520**	**-4.223**	**-4.438**	**-4.631**	**-4.942**	-	**-4.154**	**-5.644**	**-3.488**	**-4.869**	**-3.686**	**-4.423**	14
ltir	-	-	-	-	-	-	-	-	-	**-3.201**	-	**-4.913**	-	-	**-4.837**	3
y*	**-3.343**	**-3.352**	2.848	**-3.550**	-2.763	**-3.880**	**-3.803**	**-3.717**	**-3.269**	**-3.197**	**-3.735**	**-3.833**	**-4.493**	**-4.407**	**-4.137**	13
stir*	**-3.698**	**-4.856**	**-4.886**	**-5.593**	**-4.837**	**-5.390**	**-5.118**	**-3.763**	**-3.842**	**-3.663**	**-4.030**	**-3.793**	**-4.604**	**-4.600**	**-4.149**	15
ltir*	-2.832	-2.074	-2.710	-1.520	**-5.194**	**-5.763**	**-3.163**	**-3.452**	**-3.578**	**-3.858**	**-3.421**	**-3.942**	**-4.633**	**-4.806**	**-4.463**	11
	IN	ID	MY	AU	NZ	TR	EG	CA	CH	NO	SE	DK	IS			Nr. > CV
y	**-2.938**	-2.526	**-3.790**	-2.413	-2.727	**-3.751**	**-3.171**	-2.096	**-3.037**	**-3.416**	**-4.043**	**-3.766**	-2.776	-	-	8
Dp	**-7.225**	**-4.677**	**-5.873**	**-5.773**	**-6.529**	**-6.224**	**-5.737**	**-6.796**	**-6.558**	**-7.138**	**-5.935**	**-6.191**	**-4.740**	-	-	13
rer	**-3.435**	**-3.788**	**-3.440**	**-3.336**	**-3.106**	**-3.528**	-2.011	**-4.182**	**-3.225**	**-3.721**	**-3.126**	**-3.010**	**-3.783**	-	-	12
stir	**-5.552**	**-4.730**	**-4.035**	**-3.877**	**-4.148**	**-5.361**	-	**-3.844**	-2.771	**-3.538**	**-3.669**	**-3.883**	-2.797	-	-	10
ltir	-	-	**-4.021**	**-3.430**	**-5.260**	-	-	-2.870	**-3.805**	**-2.926**	**-3.326**	**-3.380**	**-3.172**	-	-	8
y*	**-4.652**	**-4.050**	**-3.833**	**-4.424**	**-4.063**	**-3.199**	**-3.754**	-2.827	-2.775	-2.899	**-2.954**	-2.766	**-3.205**	-	-	9
stir*	**-3.784**	**-4.269**	**-4.375**	**-4.814**	**-4.434**	**-5.173**	**-4.606**	**-3.745**	**-4.017**	**-4.078**	**-3.932**	**-4.050**	**-3.898**	-	-	13
ltir*	**-3.855**	**-5.090**	**-4.720**	**-4.810**	**-3.871**	**-2.925**	**-3.525**	**-3.659**	**-3.172**	**-3.222**	**-3.251**	**-3.254**	**-3.513**	-	-	13
poil*	-	**-3.286**	**3.286**	**3.286**	**3.286**	**3.286**	**3.286**	-	**3.286**	-	**3.286**	**3.286**	**3.286**	-	-	10

Table A2: ADF tests on variables in first differences. The regressions for all variables contain a constant term in the ADF regression only. The 5% critical value of the corresponding ADF statistic is -2.91, t-statistics in bold denote are significant at the 5% level.

	Levels					First Differences					Residuals of Country Models				
Country	y	Dp	rer	stir	ltir	y	Dp	rer	stir	ltir	y	Dp	rer	stir	ltir
EA	0.95	0.21	0.80	0.63	0.78	0.37	0.29	0.48	0.20	0.49	0.01	0.17	0.44	0.07	-0.12
US	0.94	0.23	-	0.56	0.74	0.30	0.22	-	0.11	0.49	0.03	0.02	-	0.03	0.00
UK	0.93	0.16	0.69	0.55	0.80	0.32	0.22	0.44	0.13	0.49	0.06	0.12	0.38	0.03	0.04
JP	0.89	0.20	0.53	0.50	0.64	0.33	0.07	0.08	0.16	0.28	0.07	0.00	0.07	-0.04	-0.07
CN	0.96	0.25	0.77	0.57	-	0.09	0.16	0.27	0.08	-	-0.01	0.09	0.16	-0.01	-
CZ	0.96	0.29	0.79	0.59	-	0.28	0.13	0.48	0.02	-	0.04	0.04	0.41	0.01	-
HU	0.93	0.30	0.78	0.64	-	0.33	0.17	0.48	0.03	-	0.09	0.11	0.43	0.00	-
PL	0.96	0.30	0.78	0.65	-	0.12	0.21	0.47	0.17	-	-0.06	0.12	0.39	0.00	-
SI	0.96	0.27	0.81	0.62	-	0.36	0.18	0.48	0.05	-	0.09	0.07	0.44	-0.01	-
SK	0.96	0.11	0.79	0.55	-	0.16	0.06	0.46	0.06	-	-0.02	-0.01	0.42	0.03	-
BG	0.94	0.10	0.74	0.35	0.69	0.12	0.02	0.27	-0.05	0.11	-0.02	0.08	0.25	0.02	0.02
RO	0.91	0.13	0.74	0.51	-	0.22	0.02	0.32	-0.02	-	0.09	0.03	0.30	-0.01	-
HR	0.94	0.28	0.81	0.54	-	0.24	0.22	0.48	-0.04	-	0.07	0.15	0.42	0.00	-
AL	0.96	0.14	0.70	0.53	-	0.02	0.05	0.32	0.03	-	0.07	0.07	0.29	0.04	-
RS	0.95	0.22	0.49	-	-	0.07	0.10	0.09	-	-	0.02	0.07	0.14	-	-
RU	0.95	0.18	0.79	0.43	-	0.26	0.11	0.21	0.02	-	-0.02	0.17	0.16	-0.05	-
UA	0.91	0.26	0.72	0.52	-	0.28	0.16	0.24	-0.01	-	0.02	0.18	0.15	0.01	-
BY	0.96	0.15	0.51	0.42	-	0.20	0.13	0.20	0.09	-	0.07	0.02	0.02	-0.04	-
GE	0.97	0.21	0.79	0.52	-	0.15	0.14	0.26	0.05	-	0.02	0.10	0.13	-0.01	-
MN	0.95	0.04	0.78	0.60	-	0.11	-0.16	0.16	0.08	-	0.01	-0.07	-0.04	-0.03	-
KG	0.96	0.28	0.76	0.59	-	0.08	0.12	0.22	-0.02	-	0.00	0.10	0.19	-0.01	-
AR	0.82	-0.10	-0.32	-0.05	-	0.15	0.05	0.06	0.00	-	0.04	-0.02	0.05	-0.02	-
BR	0.95	0.18	0.66	0.55	-	0.12	0.10	0.34	0.01	-	0.02	0.00	0.27	0.00	-
CL	0.96	0.34	0.74	-	-	0.21	0.14	0.38	-	-	0.05	0.05	0.22	-	-
MX	0.94	0.27	0.44	0.61	0.77	0.32	0.02	0.25	0.12	0.00	0.10	0.11	0.18	0.03	-0.07
PE	0.93	0.30	0.80	0.53	-	0.22	0.01	0.35	0.01	-	0.03	-0.03	0.22	-0.01	-
KR	0.96	0.20	0.67	0.60	0.71	0.20	0.10	0.32	0.12	0.22	0.04	0.06	0.23	0.02	-0.03
PH	0.96	0.22	0.64	0.59	-	0.11	-0.01	0.24	0.07	-	-0.01	-0.01	0.12	0.00	-
SG	0.96	0.13	0.76	0.48	-	0.25	0.04	0.43	0.08	-	0.03	-0.01	0.29	-0.01	-
TH	0.93	0.29	0.74	0.52	0.73	0.22	0.20	0.26	0.10	0.25	0.04	0.07	0.27	0.01	0.01
IN	0.96	0.06	0.80	0.26	-	-0.03	0.01	0.34	0.08	-	-0.03	0.00	0.27	0.04	-
ID	0.91	0.03	0.66	0.37	-	0.09	0.01	0.23	0.07	-	0.04	0.02	0.24	0.01	-
MY	0.96	0.27	0.67	0.55	0.62	0.25	0.20	0.27	0.12	0.23	0.07	0.06	0.25	0.05	0.00
AU	0.96	0.15	0.82	0.44	0.77	0.16	0.16	0.47	0.14	0.50	0.10	0.09	0.38	0.02	0.04
NZ	0.96	0.13	0.79	0.49	0.73	0.17	0.17	0.44	0.14	0.44	0.10	0.07	0.35	0.00	0.01
TR	0.95	0.21	0.78	0.53	-	0.23	0.09	0.28	0.06	-	0.03	0.06	0.23	0.03	-
EG	0.96	0.12	0.51	-	-	-0.02	0.17	0.10	-	-	0.00	0.12	-0.04	-	-
CA	0.95	0.17	0.80	0.57	0.78	0.29	0.24	0.41	0.18	0.44	0.03	0.06	0.28	0.05	0.04
CH	0.96	0.26	0.79	0.44	0.73	0.30	0.24	0.44	0.09	0.37	0.02	0.09	0.32	-0.01	-0.01
NO	0.94	0.17	0.81	0.34	0.64	0.15	0.15	0.47	0.09	0.40	0.03	0.06	0.38	0.03	0.05
SE	0.96	0.19	0.76	0.61	0.80	0.31	0.27	0.51	0.14	0.48	0.01	0.15	0.43	0.05	0.04
DK	0.89	0.24	0.81	0.55	0.82	0.28	0.26	0.48	0.16	0.53	0.00	0.11	0.39	0.04	0.08
IS	0.94	-0.05	0.55	-0.03	-0.03	0.12	0.03	0.35	0.03	-0.05	0.00	0.03	0.26	-0.03	0.00

Table A3: Average pair-wise cross-country correlations. The left-hand side panel shows the cross-country correlation for the variables in levels, the middle panel the corresponding correlations for the first-differenced data. The right-hand side panel of the table provides the according correlations for the residuals of equations across the countries.

	Domestic Variables	Foreign Variables	Coint. Rank	Trend / Intercept	p=q=lex
AL	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
AR	y, Dp, rer, stir	y*, stir*, ltir*	2	IV	1
AU	y, Dp, rer, stir, ltir	y*, stir*, ltir*	2	IV	1
BG	y, Dp, rer, stir, ltir	y*, stir*, ltir*	2	II	1
BR	y, Dp, rer, stir	y*, stir*, ltir*, poil*	1	IV	1
BY	y, Dp, rer, stir	y*, stir*, ltir*	2	IV	1
CA	y, Dp, rer, stir, ltir	y*, stir*, ltir*, poil*	1	I	1
CH	y, Dp, rer, stir, ltir	y*, stir*, ltir*	2	IV	1
CL	y, Dp, rer	y*, stir*, ltir*	2	II	1
CN	y, Dp, rer, stir	y*, stir*, ltir*, poil*	1	IV	1
CZ	y, Dp, rer, stir	y*, stir*	2	II	1
DK	y, Dp, rer, stir, ltir	y*, stir*, ltir*	3	IV	1
EA	y, Dp, rer, stir, ltir	y*, stir*, ltir*, poil*	1	IV	1
EG	y, Dp, rer	y*, stir*, ltir*	1	III	1
GE	y, Dp, rer, stir	y*, stir*, ltir*	3	II	1
HR	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
HU	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
ID	y, Dp, rer, stir	y*, stir*, ltir*	1	II	1
IN	y, Dp, rer, stir	y*, stir*, ltir*, poil*	1	III	1
IS	y, Dp, rer, stir, ltir	y*, stir*, ltir*	2	IV	1
JP	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	III	1
KG	y, Dp, rer, stir	y*, stir*, ltir*	1	II	1
KR	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	III	1
MN	y, Dp, rer, stir	y*, stir*, ltir*	2	IV	1
MX	y, Dp, rer, stir, ltir	y*, stir*, ltir*, poil*	2	I	1
MY	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	I	1
NO	y, Dp, rer, stir, ltir	y*, stir*, ltir*, poil*	2	II	1
NZ	y, Dp, rer, stir, ltir	y*, stir*, ltir*	2	I	1
PE	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
PH	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
PL	y, Dp, rer, stir	y*, stir*, ltir*	2	IV	1
RO	y, Dp, rer, stir	y*, stir*, ltir*	2	II	1
RS	y, Dp, rer	y*, stir*, ltir*	1	I	1
RU	y, Dp, rer, stir	y*, stir*, ltir*, poil*	2	II	1
SE	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	IV	1
SG	y, Dp, rer, stir	y*, stir*, ltir*	1	I	1
SI	y, Dp, rer, stir	y*, stir*, ltir*	1	IV	1
SK	y, Dp, rer, stir	y*, stir*, ltir*	2	II	1
TH	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	II	1
TR	y, Dp, rer, stir	y*, stir*, ltir*	1	II	1
UA	y, Dp, rer, stir	y*, stir*, ltir*	1	III	1
UK	y, Dp, rer, stir, ltir	y*, stir*, ltir*	1	IV	1
US	y, Dp, stir, ltir, poil	y*, ltir*	1	IV	1

Table A4: Specification of the country models.

Country	DoF	F-crit. (0.95)	y*	stir*	ltir*	poil*
EA	F(1,55)	4.016	2.949	0.188	1.467	1.725
-	-	-	(0.092)	(0.666)	(0.231)	(0.195)
US	F(1,56)	4.013	1.706	-	4.108	-
-	-	-	(0.197)	-	(0.047)	-
UK	F(1,55)	4.016	2.834	0.026	0.079	4.174
-	-	-	(0.098)	(0.873)	(0.780)	(0.046)
JP	F(1,55)	4.016	0.250	0.068	0.282	0.543
-	-	-	(0.619)	(0.795)	(0.597)	(0.464)
CN	F(1,56)	4.013	0.074	0.326	0.547	0.152
-	-	-	(0.786)	(0.570)	(0.463)	(0.698)
CZ	F(2,53)	3.172	2.821	7.865	-	0.373
-	-	-	(0.068)	(0.001)	-	(0.690)
HU	F(1,56)	4.013	3.446	0.429	0.045	2.650
-	-	-	(0.069)	(0.515)	(0.832)	(0.109)
PL	F(2,55)	3.165	0.602	6.835	0.017	2.398
-	-	-	(0.551)	(0.002)	(0.983)	(0.100)
SI	F(1,54)	4.02	5.040	12.114	0.008	3.792
-	-	-	(0.029)	(0.001)	(0.928)	(0.057)
SK	F(2,55)	3.165	1.496	0.736	2.292	1.599
-	-	-	(0.233)	(0.484)	(0.111)	(0.211)
BG	F(2,52)	3.175	0.534	3.455	0.085	0.158
-	-	-	(0.589)	(0.039)	(0.919)	(0.854)
RO	F(2,53)	3.172	0.377	3.756	1.623	2.130
-	-	-	(0.688)	(0.030)	(0.207)	(0.129)
HR	F(1,54)	4.02	0.010	5.724	3.422	3.281
-	-	-	(0.922)	(0.020)	(0.070)	(0.076)
AL	F(1,54)	4.02	0.204	0.982	0.579	0.131
-	-	-	(0.653)	(0.326)	(0.450)	(0.719)
RS	F(1,55)	4.016	2.147	0.767	14.492	1.138
-	-	-	(0.149)	(0.385)	(0.000)	(0.291)
RU	F(2,55)	3.165	3.586	0.078	1.866	0.388
-	-	-	(0.034)	(0.925)	(0.164)	(0.680)
UA	F(1,54)	4.02	5.967	0.191	1.587	0.024
-	-	-	(0.018)	(0.664)	(0.213)	(0.878)
BY	F(2,53)	3.172	1.567	1.567	1.036	0.301
-	-	-	(0.218)	(0.218)	(0.362)	(0.741)
GE	F(3,52)	2.783	2.902	4.441	0.126	2.287
-	-	-	(0.043)	(0.007)	(0.944)	(0.089)
MN	F(2,53)	3.172	1.131	3.520	0.189	1.256
-	-	-	(0.330)	(0.037)	(0.829)	(0.293)
KG	F(1,54)	4.02	0.144	0.046	0.283	0.000
-	-	-	(0.706)	(0.830)	(0.597)	(0.999)
AR	F(2,52)	3.175	0.191	5.291	0.624	1.715
-	-	-	(0.827)	(0.008)	(0.540)	(0.190)
BR	F(1,54)	4.02	0.662	0.295	0.104	0.043
-	-	-	(0.420)	(0.589)	(0.748)	(0.836)
CL	F(2,56)	3.162	3.563	0.314	5.443	0.862
-	-	-	(0.035)	(0.732)	(0.007)	(0.428)
MX	F(2,54)	3.168	1.023	0.709	1.050	1.014
-	-	-	(0.366)	(0.497)	(0.357)	(0.370)
PE	F(1,55)	4.016	0.004	0.186	0.263	0.037
-	-	-	(0.950)	(0.668)	(0.610)	(0.848)
KR	F(1,53)	4.023	2.221	1.527	0.062	4.054
-	-	-	(0.142)	(0.222)	(0.804)	(0.049)
PH	F(1,56)	4.013	1.433	0.928	0.124	0.561
-	-	-	(0.236)	(0.339)	(0.727)	(0.457)
SG	F(1,56)	4.013	1.230	5.710	1.905	0.290
-	-	-	(0.272)	(0.020)	(0.173)	(0.592)
TH	F(1,51)	4.03	2.641	0.845	1.280	0.032
-	-	-	(0.110)	(0.362)	(0.263)	(0.858)
IN	F(1,56)	4.013	0.333	1.300	0.387	0.912
-	-	-	(0.566)	(0.259)	(0.537)	(0.344)
ID	F(1,52)	4.027	1.111	3.869	2.404	0.038
-	-	-	(0.297)	(0.055)	(0.127)	(0.846)
MY	F(1,53)	4.023	0.953	2.743	0.019	0.001
-	-	-	(0.333)	(0.104)	(0.890)	(0.971)
AU	F(2,54)	3.168	1.672	0.101	0.105	0.340
-	-	-	(0.198)	(0.904)	(0.900)	(0.713)

NZ	F(2,54)	3.168	0.621	0.067	0.502	0.856
-	-	-	(0.541)	(0.935)	(0.608)	(0.430)
TR	F(1,54)	4.02	1.815	2.622	2.088	0.505
-	-	-	(0.184)	(0.111)	(0.154)	(0.481)
EG	F(1,57)	4.01	7.579	0.973	0.574	11.700
-	-	-	(0.008)	(0.328)	(0.452)	(0.001)
CA	F(1,55)	4.016	0.612	0.413	3.262	4.507
-	-	-	(0.437)	(0.523)	(0.076)	(0.038)
CH	F(2,54)	3.168	5.471	1.003	0.627	7.388
-	-	-	(0.007)	(0.374)	(0.538)	(0.001)
NO	F(2,54)	3.168	0.359	0.268	0.407	0.049
-	-	-	(0.700)	(0.766)	(0.668)	(0.952)
SE	F(1,55)	4.016	0.430	0.427	0.558	0.019
-	-	-	(0.515)	(0.516)	(0.458)	(0.892)
DK	F(3,53)	2.779	1.654	0.395	0.135	3.853
-	-	-	(0.188)	(0.757)	(0.939)	(0.014)
IS	F(2,54)	3.168	0.108	1.577	2.313	2.074
-	-	-	(0.898)	(0.216)	(0.109)	(0.136)

Table A5: F-Test for weak exogeneity of foreign variables. Critical value at the 5% level, p-values in parentheses.

Country	DoF	F-crit. (0.95)	y	Dp	rer	stir	ltir	poil
EA	F(1,60)	4.001	8.710	4.944	6.655	0.004	5.838	-
-	-	-	(0.005)	(0.030)	(0.012)	(0.951)	(0.019)	-
US	F(1,62)	3.996	21.597	0.002	-	21.136	4.160	2.220
-	-	-	(0.000)	(0.962)	-	(0.000)	(0.046)	(0.141)
UK	F(1,60)	4.001	18.843	0.548	5.349	0.013	8.350	-
-	-	-	(0.000)	(0.462)	(0.024)	(0.910)	(0.005)	-
JP	F(1,60)	4.001	1.191	16.315	2.097	5.398	0.575	-
-	-	-	(0.280)	(0.000)	(0.153)	(0.024)	(0.451)	-
CN	F(1,60)	4.001	0.068	5.748	3.453	2.031	-	-
-	-	-	(0.795)	(0.020)	(0.068)	(0.159)	-	-
CZ	F(1,59)	4.004	0.178	0.006	8.336	10.052	-	-
-	-	-	(0.675)	(0.937)	(0.005)	(0.002)	-	-
HU	F(1,60)	4.001	14.302	2.397	4.216	6.083	-	-
-	-	-	(0.000)	(0.127)	(0.044)	(0.017)	-	-
PL	F(1,59)	4.004	0.251	0.068	0.990	1.884	-	-
-	-	-	(0.618)	(0.795)	(0.324)	(0.175)	-	-
SI	F(1,58)	4.007	0.050	0.000	3.090	1.815	-	-
-	-	-	(0.824)	(0.993)	(0.084)	(0.183)	-	-
SK	F(1,60)	4.001	3.715	0.141	2.149	4.564	-	-
-	-	-	(0.059)	(0.708)	(0.148)	(0.037)	-	-
BG	F(1,58)	4.007	0.641	20.053	31.106	3.057	8.204	-
-	-	-	(0.427)	(0.000)	(0.000)	(0.086)	(0.006)	-
RO	F(1,58)	4.007	0.001	13.114	0.882	2.286	-	-
-	-	-	(0.977)	(0.001)	(0.352)	(0.136)	-	-
HR	F(1,58)	4.007	0.087	0.266	0.708	3.244	-	-
-	-	-	(0.769)	(0.608)	(0.404)	(0.077)	-	-
AL	F(1,58)	4.007	0.241	2.132	1.382	0.919	-	-
-	-	-	(0.625)	(0.150)	(0.245)	(0.342)	-	-
RS	F(1,59)	4.004	0.866	0.018	0.425	-	-	-
-	-	-	(0.356)	(0.894)	(0.517)	-	-	-
RU	F(1,60)	4.001	0.712	0.015	7.526	0.217	-	-
-	-	-	(0.402)	(0.904)	(0.008)	(0.643)	-	-
UA	F(1,58)	4.007	4.867	0.799	0.108	3.248	-	-
-	-	-	(0.031)	(0.375)	(0.743)	(0.077)	-	-
BY	F(1,57)	4.01	1.138	4.347	0.133	0.277	-	-
-	-	-	(0.291)	(0.042)	(0.717)	(0.600)	-	-
GE	F(1,57)	4.01	0.815	2.761	0.191	0.013	-	-
-	-	-	(0.371)	(0.102)	(0.663)	(0.909)	-	-
MN	F(1,57)	4.01	0.699	1.672	8.905	3.366	-	-
-	-	-	(0.407)	(0.201)	(0.004)	(0.072)	-	-
KG	F(1,59)	4.004	3.026	0.000	0.782	0.233	-	-
-	-	-	(0.087)	(0.994)	(0.380)	(0.631)	-	-
AR	F(1,56)	4.013	4.625	1.009	24.852	0.178	-	-
-	-	-	(0.036)	(0.319)	(0.000)	(0.675)	-	-
BR	F(1,58)	4.007	2.426	2.464	0.693	0.964	-	-
-	-	-	(0.125)	(0.122)	(0.409)	(0.330)	-	-
CL	F(1,60)	4.001	0.387	2.902	1.604	-	-	-
-	-	-	(0.536)	(0.094)	(0.210)	-	-	-
MX	F(1,60)	4.001	5.006	0.024	0.074	0.001	0.253	-
-	-	-	(0.029)	(0.877)	(0.786)	(0.973)	(0.617)	-
PE	F(1,59)	4.004	6.223	5.774	3.295	2.072	-	-
-	-	-	(0.015)	(0.019)	(0.075)	(0.155)	-	-
KR	F(1,58)	4.007	0.301	0.869	0.268	1.386	0.464	-
-	-	-	(0.585)	(0.355)	(0.606)	(0.244)	(0.498)	-
PH	F(1,60)	4.001	10.991	10.146	0.009	1.074	-	-
-	-	-	(0.002)	(0.002)	(0.927)	(0.304)	-	-
SG	F(1,61)	3.998	1.502	2.176	0.632	1.243	-	-
-	-	-	(0.225)	(0.145)	(0.430)	(0.269)	-	-
TH	F(1,57)	4.01	0.061	2.793	2.623	0.064	0.499	-
-	-	-	(0.806)	(0.100)	(0.111)	(0.800)	(0.483)	-
IN	F(1,60)	4.001	2.228	0.073	1.125	1.787	-	-
-	-	-	(0.141)	(0.788)	(0.293)	(0.186)	-	-
ID	F(1,57)	4.01	0.113	12.972	0.423	0.022	-	-
-	-	-	(0.738)	(0.001)	(0.518)	(0.882)	-	-
MY	F(1,59)	4.004	0.745	3.706	0.870	1.772	3.377	-
-	-	-	(0.392)	(0.059)	(0.355)	(0.188)	(0.071)	-
AU	F(1,59)	4.004	0.150	0.929	0.099	1.393	1.748	-
-	-	-	(0.700)	(0.339)	(0.754)	(0.243)	(0.191)	-

NZ	F(1,60)	4.001	0.024	0.002	4.062	8.850	0.809	-
-	-	-	(0.879)	(0.961)	(0.048)	(0.004)	(0.372)	-
TR	F(1,59)	4.004	0.068	2.161	0.003	1.142	-	-
-	-	-	(0.795)	(0.147)	(0.957)	(0.290)	-	-
EG	F(1,60)	4.001	0.314	0.001	6.818	-	-	-
-	-	-	(0.577)	(0.975)	(0.011)	-	-	-
CA	F(1,61)	3.998	1.552	0.749	1.796	6.587	2.020	-
-	-	-	(0.218)	(0.390)	(0.185)	(0.013)	(0.160)	-
CH	F(1,59)	4.004	0.342	0.618	0.112	2.401	0.013	-
-	-	-	(0.561)	(0.435)	(0.739)	(0.127)	(0.911)	-
NO	F(1,60)	4.001	13.472	0.797	1.210	10.525	2.635	-
-	-	-	(0.001)	(0.376)	(0.276)	(0.002)	(0.110)	-
SE	F(1,60)	4.001	1.801	0.000	5.436	0.727	6.137	-
-	-	-	(0.185)	(0.989)	(0.023)	(0.397)	(0.016)	-
DK	F(1,58)	4.007	0.076	4.427	0.152	7.475	0.808	-
-	-	-	(0.784)	(0.040)	(0.698)	(0.008)	(0.372)	-
IS	F(1,59)	4.004	0.262	2.252	0.388	0.044	0.636	-
-	-	-	(0.610)	(0.139)	(0.536)	(0.834)	(0.428)	-

Table A6: F-test for first order serial autocorrelation in the country models. Critical values for the 5% level, p-values in parentheses.

	Shock 1			Shock 2			Shock 3			Shock 4		
Forecast Horizon	0	20	40	0	20	40	0	20	40	0	20	40
Average contribution to forecast error variance												
y	5.20	4.89	4.92	7.21	4.24	4.31	7.33	3.24	3.36	0.74	2.82	3.07
Dp	1.11	1.43	1.57	4.77	3.11	3.44	8.78	4.92	5.10	1.28	3.25	3.53
rer	1.12	1.46	1.55	4.73	1.86	1.93	6.86	1.77	1.82	0.46	1.97	2.18
stir	1.92	1.73	1.77	5.05	2.11	2.25	8.23	2.78	2.89	1.06	2.89	3.09
ltir	1.93	1.92	1.94	2.90	1.36	1.44	3.56	1.76	1.82	0.96	1.50	1.58
Average contribution to forecast error variance per country												
EA	7.12	6.32	6.23	17.72	8.84	8.44	23.73	10.07	9.67	0.85	4.03	4.28
US	15.49	12.75	12.38	8.12	5.00	4.73	3.86	1.63	1.53	21.93	10.69	9.77
UK	5.05	4.34	4.23	2.99	1.94	1.81	4.07	4.11	3.86	1.72	2.38	2.31
CA	0.69	1.40	1.61	5.14	3.14	3.53	9.26	4.61	4.89	1.19	4.64	5.01
JP	3.32	3.58	3.59	4.72	3.73	3.59	3.62	3.04	2.96	1.63	2.12	2.10
CZ	0.78	0.78	0.74	1.79	0.60	0.47	1.14	1.15	1.06	0.24	0.03	0.03
HU	8.16	6.25	6.00	10.78	2.99	2.55	9.66	2.17	1.84	0.83	0.71	0.73
PL	0.27	0.56	0.61	1.90	1.99	2.06	3.89	3.57	3.57	0.78	1.47	1.58
SK	1.65	2.12	2.12	2.05	2.73	2.66	1.77	2.91	2.86	0.17	1.03	1.08
SI	1.61	2.00	2.00	1.18	1.64	1.63	0.59	2.26	2.27	0.51	1.09	1.14
TR	2.25	1.50	1.52	5.10	2.73	2.95	10.88	4.96	5.04	0.08	1.82	2.08
RO	0.59	0.39	0.37	0.90	1.65	1.61	4.01	3.07	2.86	0.26	0.31	0.31
BG	2.74	2.92	2.85	0.84	0.94	0.87	1.02	0.75	0.76	0.69	0.48	0.46
HR	0.97	1.82	2.16	10.77	3.25	3.74	19.66	3.15	3.40	0.19	4.66	5.32
RS	1.53	0.75	0.72	4.47	0.55	0.48	5.59	0.25	0.17	0.03	0.32	0.38
AL	1.34	1.73	1.77	3.35	1.41	1.48	4.30	1.43	1.57	0.12	0.97	1.13
RU	0.92	1.84	2.10	2.81	4.44	5.07	9.84	4.15	4.51	1.00	4.89	5.41
BY	1.00	1.93	2.03	0.86	1.95	2.02	0.77	0.92	0.95	0.46	0.91	0.96
GE	0.73	1.26	1.38	6.48	1.26	1.30	13.61	1.83	1.64	0.88	2.76	2.96
KG	0.31	0.64	0.71	2.41	1.02	1.07	2.76	0.83	0.89	1.04	0.61	0.60
MN	1.97	1.31	1.52	10.74	3.64	4.23	16.48	4.41	4.99	0.56	6.72	7.48
UA	0.31	0.18	0.16	0.58	1.01	1.06	1.94	2.50	2.43	0.88	0.30	0.29
...	...	...	...	...	...	...	...	...	...	...	...	...

Table A7: Generalized Forecast Error Variance Decompositions at the 0, 20 and 40 forecast horizon. Shock 1 corresponds to a +1% shock to US real GDP, shock 2 to a +1% shock to euro area real GDP, shock 3 to a +50bp shock to euro area short term interest rates and shock 4 to a +50% increase in the oil price.

	EA	US	UK	JP	CN	CZ	HU	PL	SI	SK	BG	RO	HR	AL	RS
H0: $r = 0$, H1: $r > 1$	237.5	202.7	200.4	244.8	279.8	129.5	136.8	159.2	147.7	130.8	298.0	116.8	145.0	170.7	69.7
	(134.2)	(111.7)	(123.0)	(117.7)	(101.0)	(73.1)	(91.8)	(91.8)	(91.8)	(82.4)	(111.5)	(82.4)	(91.8)	(91.8)	(47.2)
H0: $r < 1$, H1: $r \geq 2$	136.3	115.3	121.9	139.8	79.9	53.8	84.1	83.4	90.7	61.4	129.0	66.9	79.8	73.1	32.1
	(101.0)	(82.6)	(91.8)	(87.6)	(71.6)	(50.0)	(64.5)	(64.5)	(64.5)	(57.2)	(82.4)	(57.2)	(64.5)	(64.5)	(28.9)
H0: $r \leq 2$, H1: $r \geq 3$	81.9	58.9	63.1*	71.1	42.2*	26.8*	46.6	21.4*	44.6	24.7*	79.4	27.7*	39.4*	34.9*	9.0*
	(71.6)	(57.5)	(64.5)	(61.4)	(45.9)	(30.8)	(41.0)	(41.0)	(41.0)	(35.9)	(57.2)	(35.9)	(41.0)	(41.0)	(14.4)
H0: $r \leq 3$, H1: $r \geq 4$	35.0*	25.5*	29.4	33.7*	10.7	10.3	17.4*	8.4	13.3*	7.7	40.5	12.1	12.2	8.7	-
	(45.9)	(36.1)	(41.0)	(39.0)	(23.6)	(15.3)	(21.0)	(21.0)	(21.0)	(18.1)	(35.9)	(18.1)	(21.0)	(21.0)	(-)
H0: $r \leq 4$, H1: $r \geq 5$	12.7	10.6	12.2	14.8	-	-	-	-	-	-	15.3*	-	-	-	-
	(23.6)	(18.3)	(21.0)	(20.0)	(-)	(-)	(-)	(-)	(-)	(-)	(18.1)	(-)	(-)	(-)	(-)
	RU	UA	BY	GE	MN	KG	AR	BR	CL	MX	PE	KR	PH	SG	TH
H0: $r = 0$, H1: $r > 1$	280.3	200.0	303.0	184.8	251.9	147.2	195.5	109.2	75.3	348.9	138.7	208.1	112.4	89.1	179.1
	(91.6)	(78.3)	(91.8)	(82.4)	(91.8)	(91.8)	(91.8)	(101.0)	(57.2)	(106.6)	(91.8)	(106.4)	(91.8)	(69.2)	(111.5)
H0: $r < 1$, H1: $r \geq 2$	116.8	105.9	99.4	103.8	121.2	71.5	77.6	66.2*	41.6	177.0	74.9	125.3	63.4*	52.2	108.3
	(64.3)	(54.3)	(64.5)	(57.2)	(64.5)	(64.5)	(64.5)	(71.6)	(35.9)	(78.6)	(64.5)	(78.3)	(64.5)	(47.2)	(82.4)
H0: $r \leq 2$, H1: $r \geq 3$	53.8	47.0	51.2	63.8	56.1	38.4*	39.3*	35.9	11.9*	60.3	41.0	55.9	32.9	25.5*	68.4
	(40.9)	(34.0)	(41.0)	(35.9)	(41.0)	(41.0)	(41.0)	(45.9)	(18.1)	(54.4)	(41.0)	(54.3)	(41.0)	(28.9)	(57.2)
H0: $r \leq 3$, H1: $r \geq 4$	24.8*	7.7*	15.0*	25.2*	21.3	18.6	10.5	10.6	-	29.4*	15.1*	23.6*	12.5	5.2	32.8*
	(20.8)	(17.2)	(21.0)	(18.1)	(21.0)	(21.0)	(21.0)	(23.6)	(-)	(34.0)	(21.0)	(34.0)	(21.0)	(14.4)	(35.9)
H0: $r \leq 4$, H1: $r \geq 5$	-	-	-	-	-	-	-	-	-	11.0	-	8.7	-	-	12.5
	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(17.2)	(-)	(17.2)	(-)	(-)	(18.1)
	IN	ID	MY	AU	NZ	TR	EG	CA	CH	NO	SE	DK	IS	-	-
H0: $r = 0$, H1: $r > 1$	118.5	189.6	185.9	204.3	166.2	112.0	82.5	199.8	197.9	199.1	233.3	234.5	213.3	-	-
	(87.6)	(82.4)	(95.2)	(123.0)	(95.2)	(82.4)	(54.3)	(106.6)	(123.0)	(122.7)	(123.0)	(123.0)	(123.0)	(-)	(-)
H0: $r < 1$, H1: $r \geq 2$	62.6	100.9	113.0	102.7	97.7	39.0*	25.5*	90.9	113.1	122.2	120.4	133.5	140.7	-	-
	(61.4)	(57.2)	(69.2)	(91.8)	(69.2)	(57.2)	(34.0)	(78.6)	(91.8)	(91.6)	(91.8)	(91.8)	(91.8)	(-)	(-)
H0: $r \leq 2$, H1: $r \geq 3$	33.9*	47.6	63.1	69.5	46.3*	19.6	7.1	51.6*	62.1*	66.4	70.4	78.6	82.1	-	-
	(39.0)	(35.9)	(47.2)	(64.5)	(47.2)	(35.9)	(17.2)	(54.4)	(64.5)	(64.3)	(64.5)	(64.5)	(64.5)	(-)	(-)
H0: $r \leq 3$, H1: $r \geq 4$	12.9	18.3	30.7	36.9*	22.4	4.3	-	24.1	33.3	38.5*	35.3*	29.1*	37.4*	-	-
	(20.0)	(18.1)	(28.9)	(41.0)	(28.9)	(18.1)	(-)	(34.0)	(41.0)	(40.9)	(41.0)	(41.0)	(41.0)	(-)	(-)
H0: $r \leq 4$, H1: $r \geq 5$	-	-	12.5*	16.1	8.1	-	-	9.6	10.1	12.3	7.5	5.9	11.8	-	-
	(-)	(-)	(14.4)	(21.0)	(14.4)	(-)	(-)	(17.2)	(21.0)	(20.8)	(21.0)	(21.0)	(21.0)	(-)	(-)

Table A8: Trace statistic for testing the cointegration rank. Critical values for at the 5% level provided in parentheses. The cointegration rank implied by the test statistic is marked by a '*'. As explained in Appendix B, the rank might differ from the one of the final model (see Table A4).

	EA	US	UK	JP	CN	CZ	HU	PL	SI	SK	BG	RO	HR	AL	RS
H0: Case III, H1: Case IV	9.6*	0.5	4.9*	0.1	1.1	3.7	0.5*	41.5*	12.1*	10.8*	3.2	0.9	9.6*	6.8*	0.0
	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)	(6.0)	(3.8)	(6.0)	(6.0)	(6.0)	(6.0)	(6.0)	(3.8)	(6.0)	(3.8)
H0: Case II, H1: Case III	12.9	24.3*	8.4	24.9*	94.1*	2.1	7.0	7.7	1.1	0.6	0.9	0.4	0.1	3.6	0.5
	(15.5)	(12.6)	(15.5)	(15.5)	(14.1)	(11.1)	(14.1)	(12.6)	(12.6)	(12.6)	(14.1)	(12.6)	(14.1)	(12.6)	(12.6)
H0: Case I, H1: Case II	5.9	9.7	0.1	5.3	19.4	6.8*	0.0	1.9	9.7	33.6	11.7*	0.9	8.0	10.2	0.6
	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)	(6.0)	(3.8)	(6.0)	(6.0)	(6.0)	(6.0)	(6.0)	(3.8)	(6.0)	(3.8)
	RU	UA	BY	GE	MN	KG	AR	BR	CL	MX	PE	KR	PH	SG	TH
H0: Case III, H1: Case IV	0.2	2.8	10.5*	7.2	34.9*	9.2*	21.3*	11.5*	5.1	2.4	9.8*	1.3	8.0*	0.5	3.3
	(6.0)	(3.8)	(7.8)	(7.8)	(6.0)	(6.0)	(6.0)	(3.8)	(6.0)	(6.0)	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)
H0: Case II, H1: Case III	2.8	15.2*	6.7	4.1	11.9	3.4	2.3	2.1	0.9	1.6	18.4	19.6	8.8	12.6*	4.3
	(12.6)	(14.1)	(11.1)	(11.1)	(12.6)	(12.6)	(12.6)	(14.1)	(11.1)	(14.1)	(14.1)	(15.5)	(14.1)	(14.1)	(15.5)
H0: Case I, H1: Case II	6.0*	6.4	8.0	11.1*	11.7	4.5	4.7	2.4	7.2*	4.4	5.9	0.1	1.9	0.1	9.3*
	(6.0)	(3.8)	(7.8)	(7.8)	(6.0)	(6.0)	(6.0)	(3.8)	(6.0)	(6.0)	(3.8)	(3.8)	(3.8)	(3.8)	(3.8)
	IN	ID	MY	AU	NZ	TR	EG	CA	CH	NO	SE	DK	IS	-	-
H0: Case III, H1: Case IV	0.5	0.1	0.1	17.9*	3.0	0.9	1.4	2.8	15.9*	2.4	4.6*	35.2*	22.3*	-	-
	(3.8)	(3.8)	(3.8)	(6.0)	(6.0)	(3.8)	(3.8)	(3.8)	(6.0)	(6.0)	(3.8)	(7.8)	(7.8)	(-)	(-)
H0: Case II, H1: Case III	37.3*	7.3	1.2	14.1	3.8	3.2	22.9*	4.8	8.9	1.6	2.8	7.9	2.0	-	-
	(14.1)	(14.1)	(15.5)	(14.1)	(14.1)	(14.1)	(12.6)	(15.5)	(14.1)	(14.1)	(15.5)	(12.6)	(12.6)	(-)	(-)
H0: Case I, H1: Case II	5.9	10.5*	0.7	0.6	0.5	0.8	3.9	1.7	4.8	11.8*	6.9	19.7	8.5	-	-
	(3.8)	(3.8)	(3.8)	(6.0)	(6.0)	(3.8)	(3.8)	(3.8)	(6.0)	(6.0)	(3.8)	(7.8)	(7.8)	(-)	(-)

Table A9: Nested likelihood ratio test on specification of deterministic terms. Critical values for the trace statistic at the 5% level provided in parentheses. The specification of the deterministic terms supported by the test is the alternative hypothesis (H1) of the respective row marked by a '*'. For Canada, Malaysia, Mexico, New Zealand, Romania, Serbia and Turkey the test points to 'Case I'. Note that specification indicated by the test might deviate from that of the final model, which is provided in Table A4.

Country	$(\Delta y, \Delta y^*)$	$(\Delta stir, \Delta stir^*)$	$(\Delta ltir, \Delta ltir^*)$	Country	$(\Delta y, \Delta y^*)$	$(\Delta stir, \Delta stir^*)$	$(\Delta ltir, \Delta ltir^*)$
EA	0.722	0.088	0.864	BR	0.512	0.208	-
	(9.402)	(5.250)	(11.421)		(1.768)	(0.514)	(-)
US	0.711	-	0.597	CL	0.763	-	-
	(6.815)	(-)	(5.077)		(5.016)	(-)	(-)
UK	1.174	0.384	0.943	MX	1.198	1.867	-0.655
	(8.966)	(3.365)	(10.544)		(7.892)	(1.909)	(-0.994)
JP	0.805	0.047	0.451	PE	0.349	-0.450	-
	(4.736)	(3.703)	(4.598)		(1.542)	(-0.731)	(-)
CN	0.282	0.030	-	KR	0.074	0.195	0.997
	(1.465)	(0.552)	(-)		(0.393)	(1.799)	(3.157)
CZ	0.661	-0.046	-	PH	0.496	1.485	-
	(6.750)	(-1.736)	(-)		(2.139)	(2.518)	(-)
HU	0.904	-0.011	-	SG	1.826	0.847	-
	(6.262)	(-0.333)	(-)		(8.259)	(7.685)	(-)
PL	0.265	-0.331	-	TH	0.681	1.243	0.687
	(1.352)	(-8.679)	(-)		(2.981)	(3.968)	(2.442)
SI	1.554	-0.054	-	IN	-0.073	0.338	-
	(7.472)	(-0.799)	(-)		(-0.364)	(1.074)	(-)
SK	1.190	-0.280	-	ID	0.148	-0.200	-
	(5.237)	(-8.068)	(-)		(1.178)	(-0.489)	(-)
BG	1.110	-0.004	3.170	MY	0.906	0.699	0.715
	(5.259)	(-0.364)	(1.124)		(9.102)	(6.084)	(4.874)
RO	0.719	0.690	-	AU	0.179	0.189	1.139
	(2.821)	(6.043)	(-)		(1.454)	(2.850)	(11.198)
HR	1.068	-0.035	-	NZ	0.616	0.815	1.097
	(3.575)	(-0.180)	(-)		(5.719)	(5.161)	(8.428)
AL	-0.338	0.025	-	TR	1.160	-0.413	-
	(-0.785)	(0.363)	(-)		(3.801)	(-1.529)	(-)
RS	1.727	-	-	EG	-0.238	-	-
	(4.300)	(-)	(-)		(-0.804)	(-)	(-)
RU	0.973	-2.554	-	CA	0.888	0.790	0.672
	(5.282)	(-2.089)	(-)		(16.274)	(8.452)	(10.974)
UA	2.302	-0.054	-	CH	0.604	0.263	0.598
	(8.529)	(-1.324)	(-)		(4.896)	(1.904)	(5.047)
BY	0.284	0.117	-	NO	1.125	0.498	1.019
	(1.320)	(3.242)	(-)		(4.181)	(3.863)	(8.746)
GE	0.417	0.074	-	SE	1.420	0.431	1.169
	(1.738)	(4.220)	(-)		(7.313)	(6.971)	(12.718)
MN	0.177	0.001	-	DK	1.229	0.376	1.026
	(0.806)	(0.105)	(-)		(8.865)	(6.616)	(21.182)
KG	0.484	-0.052	-	IS	0.799	1.195	0.228
	(2.032)	(-0.829)	(-)		(1.854)	(3.103)	(0.742)
AR	0.032	0.146	-		-	-	-
	(0.176)	(0.584)	(-)		-	-	-

Table A10: Impact elasticities for real output, semi-elasticities for interest rates. T-statistics in parentheses.

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