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THE TRANSMISSION OF INTERNATIONAL SHOCKS TO CIS ECONOMIES: A GLOBAL VAR APPROACH

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Abstract

This paper employs a Global Vector Auto Regressive (GVAR) model to study the evolution of the response of the Commonwealth of Independent States (CIS) to foreign output and oil price shocks. During a two-decade observation period, cross-country trade and financial linkages experience notable changes. We find CIS countries highly sensitive to global and regional shocks, with that sensitivity increasing after the global financial crisis. CIS countries show strongest responses to output shocks originating in the US, Russia and within the region itself, but their sensitivity to euro area shocks also increases substantially. Despite growing trade relations with China, the responses of CIS countries to output shocks originating in China are still relatively moderate.

Keywords: international shocks, cross-country spillovers, CIS, Global VAR.

JEL classification: C32, F42, F43, E32

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1. Introduction

With the breakup of the Soviet Union, a number of newly minted economies emerged on the global stage. Many of these countries became members of the Commonwealth of Independent States (CIS), an arrangement intended to serve as a platform for coordination of regional economic and political development. Over recent decades, increasing integration with the global economy has raised a set of concerns related to the vulnerability of CIS economies to international shocks. Moving from central planning towards market economies and following the liberalization of financial flows together with higher degree of openness, most CIS countries experienced hard periods of economic slowdown, hyperinflation, as well as considerable volatility due to the changing external environment (see e.g. Roaf et al., 2014).

Although significant structural changes in domestic economies and global integration resulted in the development of a set of heterogeneous emerging economies with specific features, CIS countries are deeply interrelated due to common economic, geographic and political issues. International shocks faced by an individual country in the region may be amplified though various spillover channels. This emphasizes the importance of a multilateral perspective that considers cross-country linkages in analyzing the response of CIS economies to international shocks.

In this paper, we construct a Global Vector Auto Regressive (GVAR) model to examine the response of several CIS countries to output shocks in the US, euro area, China and Russian Federation, as well as to regional CIS output shocks.[1] We also examine how these responses change over time as international linkages (trade and financial relations, in particular) of the CIS countries undergo notable shifts. We follow a model approach similar to that used in Feldkircher (2015) and Feldkircher and Korhonen (2014), complemented with features allowing to examine the changes in responses to shocks in a similar vein to Fadejeva et al. (2017) and Cesa-Bianchi et al. (2012).

The main contributions of this paper relate to analysis of CIS economies. First, we examine the changes in the responses of CIS economies to output shocks originating in different regions for the first time. Second, we examine the effects of shocks originating specifically from Russia, with developments in recent years providing topical insights. To our best knowledge, this work is the first to examine the evolution of the decomposition of direct and

[1] Data problems limit our “CIS region” to five economies: Azerbaijan, Belarus, Georgia, Kazakhstan and Ukraine. Georgia left the organization in 2008 and Ukraine never ratified its membership, but both countries otherwise have tight relations with countries in the region. These economies together accounted on average for 80 % of the region’s GDP (in PPP terms, excluding Russia) during the 2000–16 period. We treat Russia separately in our analysis due to its relative size compared to other countries in the region.

indirect effects from trade and financial linkages by extending slightly the approaches applied in Fadejeva et al. (2017) and Cesa-Bianchi et al. (2012).

The rest of the paper proceeds as follows. Section 2 reviews the most relevant previous literature related to the topic. Section 3 presents stylized facts on increasing integration of the CIS region for providing further motivation on our research questions. The analytical framework is presented in section 4 and data and model setup in section 5. Results are discussed in section 6, and section 7 concludes.

2. Previous literature

The Global Vector Auto Regressive (GVAR) framework has become a popular approach in investigating transmission of international shocks, including applications examining the effects of foreign output shocks as surveyed in Chudik & Pesaran (2016). The existing literature suggests important effects originating from cross-border transmission of output shocks, especially from larger economies to smaller ones such as the US (Feldkircher & Huber, 2016) the euro area (Hájek & Horváth, 2014) and China (Gauvin & Rebillard, 2018; Dreger & Zhang, 2014). There is also evidence that these effects fluctuate substantially over time (Cesa-Bianchi et al., 2012; Dees & Saint-Guilhem, 2010).

The most relevant literature for our study are the applications of the GVAR framework in the context of the CIS countries. Feldkircher (2015) examines the transmission of the US and EU shocks to Central, Eastern and Southeastern Europe (CESEE) and CIS with a GVAR model comprising 43 countries and based on the time period of 1995–2011. Following a 1 % shock to euro area or US output, he finds that the GDP in the CIS countries increases in long term on average by 0.9 % and 0.7 %, respectively. He further supports the importance of regional interdependencies within CIS and argues that the effect of oil price hikes for oil-importing countries in the region is compensated by economic expansion in Russia.

In addition to important regional interdependencies and linkages to major developed economies, CIS countries are increasingly connected to the rest of the emerging world. The growing importance of the Chinese economy in the global economy has also raised its profile in the CIS region. Feldkircher & Korhonen (2014) study the transmission of Chinese shocks to the rest of the world, including CIS countries. Their findings, which are based on a GVAR model of 52 economies covering the period 1995–2011 suggest that a 1 % shock to Chinese real output translates to a roughly 0.2 % rise in output of CIS countries over the long term.

More recently, Fadejeva et al. (2017) examine spillovers from the euro area and the US to other regions in the global economy, including a number of CIS countries. Their GVAR model, which includes 42 countries and covers 1995–2013, focuses on the effects of credit shocks and aggregate demand shocks. The analysis extends to separate direct and indirect channels of influence. The results suggest that the CIS countries are among the economies experiencing the most pronounced spillovers from foreign credit and demand shocks. These shocks have historically played an important role in GDP fluctuations of CIS countries. Spillover effects from shocks originating in the US are even stronger for the CIS countries than shocks originating in the euro area, with the median long-term response of the CIS countries to a 1 % aggregate demand shock amounting to about 4 % for US shocks and 3 % for euro area shocks. The large role of US shocks mostly reflects the indirect impacts of US shocks on CIS economies.

The impact of regional or Russia-originated shocks has not been examined in the GVAR framework, but there exists some evidence on the significance of these shocks on various CIS economies. Alturki et al. (2009) find from a panel specification that a 1 % shock to Russian GDP is associated with a 0.35–0.45 % increase in the GDP of CIS countries. They also estimate separate VAR models for several CIS countries to examine the effect of Russian growth on them. They find that a 2 % shock on Russian output is associated with a 0.6–2 % response in the GDP of some CIS countries, but the effect is not statistically significant for all countries. The findings further suggest that regional spillovers are more important than global spillovers for most CIS economies.

There are also several studies providing support for the importance of regional spillovers for CIS inflation, including Comunale & Simola (2018), Faryna (2016) and Becker & Fidrmuc (2013). The effects of regional spillovers on CIS exchange rate development are considered in Charemza et al. (2009) and Dreger & Fidrmuc (2011).

3. Stylized facts on the increasing global integration of CIS economies

As CIS economies shifted from transition to market economies over the past two decades, they also integrated with the global economy. As small, fairly open economies, the CIS countries today are sensitive to the external environment. Indeed, the global financial crisis had substantial repercussions for the CIS region, demonstrating that unfavorable external events can have a considerable effect on regional economic development.

To illustrate the increasing importance of the global economy for the CIS region, Table 1 provides real GDP cross-county correlations for pre- and post-crisis periods. It shows considerable changes for the major economies and CIS countries, as also suggested in earlier literature (e.g. Ductor & Leiva-Leon, 2016; Fidrmuc et al., 2014). Correlation between US and euro area output more than doubles from 0.36 to 0.87, while the correlation between the US and Russian output increases from 0.52 to 0.7. Despite China's rise, the correlation of Chinese output with the US and euro area output turns negative. For Russia, it declines substantially from 0.85 to 0.22.

For the CIS region, average cross-country output correlations with all countries have doubled since the global financial crisis. In particular, CIS output correlation with the US, euro area and China increased from 0.16 to 0.28 on average. The Russian economy remains the most important counterpart; its output correlation with the CIS increased from 0.25 to 0.58. Average cross-country correlation within the region (i.e. between individual CIS countries) increased substantially from 0.08 to 0.41, indicating that regional developments have become much more important since the global financial crisis.

In line with global trends, foreign trade flows of the CIS economies have grown substantially. Their market shares in global trade have risen over the two decades, and today many CIS economies are more open and more dependent on foreign trade than the world average. Indeed, trade-to-GDP ratios now exceed 100 % in some CIS countries. International capital flows to CIS countries have also increased.

Although international openness is crucial for creating growth possibilities for small economies in today's globalized economic environment, it necessarily brings with it higher sensitivity to international shocks. The nature and origins of these shocks has evolved as geographical patterns of trade and financial linkages have shifted within in the CIS countries and globally. As can be seen from Figures 1 and 2, the main trend in global trade relations has been the sharp increase in China's trading presence in recent decades. The literature backs up the notion that the sensitivity of all regions to Chinese shocks has increased (e.g. Ahuja & Nabar, 2012; Cesa-Bianchi et al., 2012). The development of global financial linkages has been much more stable in general with the U.S. and the euro area continuing to dominate and China still playing a modest role.[2]

In line with global trends, China's share of CIS trade has more than doubled from an average share of 5 % during 2001–04 to 11 % during 2013–16. The share of euro area countries in CIS trade has also increased, while the Russian share has shrunk. In the end of our observation period, we see that the euro area becomes the most important trading partner of the CIS countries, surpassing even Russia. On the financial side, the US and euro area see growing shares, while Russia's share decreases.

There is, however, variation across countries within the CIS bloc. The euro area is the most important trading partner for the energy exporters Azerbaijan and Kazakhstan, whereas Russia is still a larger partner for Belarus and Ukraine in the period 2013–16. China's share is the largest in Kazakhstan's trade, while, despite an increase in recent years, for the other CIS countries it is still quite small for other CIS countries. For most of CIS countries, the share of intra-region trade has increased.

[2] We take our trade data from IMF DOTS and financial data from IMF CPIS. These data sets are described in detail in section 5.

4. The Global VAR model

In this section, we describe the analytical framework used for studying the transmission of international shocks to CIS economies from the global perspective. Given that CIS economies are closely linked with each other and integrated with the rest of the world, our analysis requires a tool that can explicitly handle cross-unit interdependencies. Panel VAR (PVAR) models that facilitate study of transmission of shocks across units have emerged as powerful tools in examining economic issues in an interdependent world.[3] The complexity of panel VARs generates several estimation problems related to dimensionality[4] and shock identification issues[5].

Thus, empirical literature usually does not utilize all distinguishing features of PVARs simultaneously. In particular, a Global VAR model provides a practical macroeconomic framework that accounts for cross-country interdependencies, maintains a simple structure and deals with dimensionality problems. Chudik & Pesaran (2016) provide a comprehensive survey of GVAR modeling and examine both the theoretical foundations of the approach and its numerous empirical applications.

We follow the GVAR approach presented in Pesaran, Schuermann & Weiner (2004), and further developed in Dees, di Mauro, Pesaran & Smith (2007, hereafter DdPS).[6] The DdPS model has become a starting point for various studies[7] which deal with GVAR models. The model is usually elaborated by composing a set of individual VAR models representing each N country in the panel. Each individual model includes domestic endogenous variables along with weakly exogenous foreign and global variables. This implies the following structure of VARX*(p_i, q_i): [8]

$$\Phi_i(L, p_i)X_{it} = a_{i0} + \Lambda_i(L, q_i)X_{it}^* + \Psi_i(L, q_i)D_t + u_{it} \,, \tag{1}$$

[3] For further discussion on Panel VAR and its practical implications, see Canova & Ciccarelli (2013).

[4] This problem may arise as the number of endogenous variables may easily exceed the number of observations.

[5] Ordering of the countries for shock orthogonalization is challenging given that, as Galesi & Lombardi (2009) argue, "in such a multi-country setting there is not a clear economical a priori knowledge which can establish a reasonable ordering of the countries."

[6] For the technical procedure of model estimation, we use an open source Matlab toolbox for modeling DdPS-GVAR provided by Smith & Galesi (2014).

[7] See, for example Galesi & Lombardi (2009), Harahap et al. (2016) and Feldkircher (2013).

[8] VARX* frameworks with weakly exogenous I (1) regressors have been developed by Harbo et al. (1998) and Pesaran et al. (2000).

for $i = 1, 2, 3, \dots, N$ and $t = 1, \dots, T$, where X_{it} is a set of country-specific variables (domestic) and $\Phi_i(L, p_i)$ is the matrix lag polynomial of related coefficients; a_{i0} is a $k_i \times 1$ vector of fixed intercepts; X_{it}^* is a set of foreign-specific variables and $\Lambda_i(L, q_i)$ is the matrix lag polynomial of the associated coefficients; D_t is a set of common global variables and $\Psi_i(L, q_i)$ is the matrix lag polynomial of the associated coefficients; u_{it} is a $k_i \times 1$ vector of idiosyncratic, serially uncorrelated country-specific shocks with $u_{it} \sim iid(0, \sum_{ii})$.

The lag order of p_i is associated with domestic variables and may differ for each i. For foreign-specific and global variables the lag order is determined by q_i. For each country ,i, p_i and q_i are chosen by minimizing the Akaike information criterion (AIC) with the assumption that $p_i \geq q_i$ to ensure the relative importance of domestic variables. Recent studies that utilize a GVAR framework find that cross-country data share a common stochastic trend, so including cointegration relationships in each individual model is required. This, in turn, results in the estimation of a set of individual vector error correction models with weakly exogenous components (VECMX*). In such models, weakly exogenous variables are included in the cointegration equation to account for the log-run relationships between domestic variables and their foreign counterparts.

A set of domestic variables X_{it} typically includes inflation, real output, real exchange rate, nominal short-term interest rate and other key macroeconomic indicators (see e.g. Pesaran, Schuermann and Weiner, 2004; DdPS, 2007). A set of foreign specific variables X_{it}^* are constructed by weighting corresponding domestic variables of other countries in the panel. More specifically, each foreign-specific variable for individual country is a weighted average of domestic variables of other countries:

$$X_{it}^* = \sum_{j=1}^{N} \omega_{ij} X_{it}, \qquad (2)$$

where $j = 1, 2, 3, \dots, N$; ω_{ij} is a set of weights such that $\sum_{j=1}^{N} \omega_{ij} = 1$ that are typically based on the bilateral trade flows across countries in the panel.

After the estimation of individual country-specific VECMX* models they are linked through the weight matrix and then combined in a GVAR model. The weight matrix comprises individual sets of weights ω_{ij} and represents the strength of cross-country relationships. Existing studies provide two ways of constructing a weight matrix: fixed or time-varying. A *fixed-weight matrix* is constructed using the data for cross-country weights for a specific year or a period average. Weights remain constant for the entire period of the estimation. In contrast, a *time-varying matrix* comprises a set of weight matrices computed for each period of the dataset. The makes it possible to capture structural changes in cross-country relationships.

Given, as discussed in section 3, that international trade composition and financial linkages change over time, the assumption of constant weights might be too restrictive for CIS economies and thus would affect the robustness of results. In addition, trade and financial relationships of major developed economies have changed in recent years due to the growing importance of China and other emerging economies. Hence, we use time-varying weights and analyze how structural changes in the trade composition and financial linkages affect the propagation of foreign shocks to specific countries.

Global variables usually include oil prices, prices for other commodities or both. There are several ways to model global variables in the GVAR framework. One way is to treat them as domestic variables for a specific country. Here, their dynamics are determined endogenously in an individual VECMX* model. Global variables are typically included in the US individual model as the US plays a dominant role in the world economy. However, this assumption may be too restrictive if the importance of other developed and emerging economies is crucial. Alternatively, we can use a "dominant unit" model (Chudik & Pesaran, 2013; Smith & Yamagata, 2011). This type of model structure allows the inclusion of endogenous relationships between global variables within the VAR model, as well as feedback variables from all countries in the panel based on their importance on the world market. A dominant unit model takes the following form:

$$\Theta(L,\tilde{p})\, D_t = \tilde{a}_0 + \Gamma(L,\tilde{q}) \sum_{i=1}^{N} \widetilde{\omega}_i X_{it} + \tilde{u}_t\,, \qquad (3)$$

where D_t is a set of global variables and $\Theta(L,\tilde{p})$ is the matrix lag polynomial of related coefficients; $\tilde{a}_0$ is a $k \times 1$ vector of fixed intercepts; $\tilde{X}_{it} = \sum_{i=1}^{N} \widetilde{\omega}_i X_{it}$ is a set of weighted average feedback variables and $\Gamma(L,\tilde{q})$ is the matrix lag polynomial of the associated coefficients; and $\tilde{u}_t$ is a $k \times 1$ vector of idiosyncratic, serially uncorrelated country-specific shocks with $\tilde{u}_t \sim iid(0,\sum_{ii})$.

The estimated GVAR model can now be used to compute Generalized Impulse Response Functions (GIRFs) that account for important interdependencies across countries as in Pesaran and Shin (1998). GIRFs are insensitive to ordering of variables, so they are not used for identification of structural shocks in the VAR model. However, the GVAR framework incorporates a weak exogeneity assumption that allows identification of country-specific shocks where cross-country residual correlation and country-specific serial residual correlation is low.

5. Data and model setup

This section introduces our data used for estimating the model. We then present the GVAR model setup and discuss the main diagnostic tests conducted for the model. The key features of our GVAR model are summarized in Table 2 and descriptive statistics of individual country data are specified in Table 3 (A and B).

5.1. Data

Our GVAR model includes five CIS economies: Azerbaijan, Belarus, Georgia, Kazakhstan, and Ukraine.[9] We do not include Russia in the CIS group as its size affects analysis for the rest of CIS countries. Instead, we treat Russia separately and study the response of our CIS region to Russian output shocks. We also include 23 other developed, developing and emerging economies: United States, euro area (modeled as a single region), Australia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Hungary, Iceland, India, Indonesia, Japan, Korea, Mexico, New Zealand, Norway, Poland, Romania, Sweden, Turkey and United Kingdom. Thus, we have a total of 30 cross-section units in the GVAR model with the countries covering about 80 % of world PPP-adjusted GDP according to the World Bank database.[10]

Each individual country model includes four domestic variables: consumer inflation, real output, nominal short-term interest rate and real exchange rate. Our dataset covers the period 2001Q1 – 2016Q4, which gives 64 quarterly observations. The time span for the analysis covers both the global financial crisis of 2007–2008 and the recent drop in oil prices accompanied with the recession in CIS economies. Our starting point reflects the data limitations. Most of the country data comes from the IMF IFS database. Like Feldkircher (2013), we use the regional aggregate for the euro area from the IMF IFS calculated on a rolling basis.

For the *real output* (y), we use logarithms of seasonally adjusted real GDP $y = \ln(GDP_t)$ indexed to annual average of 2010=100. The data for Australia, Brazil, Canada, Chile, India, Indonesia, Japan, Korea, Mexico, New Zealand, Turkey and Russian Federation are taken from the OECD database in real terms and seasonally adjusted. The data for the euro area, Czech Republic, Denmark, Bulgaria, Hungary, Iceland, Norway, Romania, Sweden and United Kingdom comes from the Eurostat in real terms and seasonally adjusted. The US real and seasonally adjusted GDP data come from the US Bureau of Economic Analysis. Real, but not seasonally adjusted, data for China and Georgia come from the IFS IMF. For Belarus, we take nominal GDP from the IFS IMF and deflate it by CPI. The data for real GDP for Ukraine, Kazakhstan and Azerbaijan come from national sources. For the seasonal adjustment of the data, we use the X12 multiplicative method.

[9] As noted, Ukraine and Georgia are not official members of CIS. We include them, nevertheless, because of their close ties with official CIS members.

[10] The scope of several earlier studies: Feldkircher (2013) = 43 units and 90 % of world coverage; Gauvin & Rebillard (2015) = 36 units and 88 % of world coverage; and Dees et al. (2007) = 33 units and 78 % of world coverage.

For *consumer price inflation* (dp) (in line with earlier studies using the GVAR approach), we take the first log-differences of seasonally adjusted Consumer Price Index: $\Delta p = \ln(CPI_t) - \ln(CPI_{t-1})$ to obtain percentage change of consumer prices. For all countries, we use the CPI index from IMF IFS. All CPI time series have been seasonally adjusted using the X12 additive method.

For *real exchange rate* (e), we use logarithms of nominal exchange rate indexed to 2010 average and deflated by domestic consumer price index: $e = \ln(NFX_t) - \ln(CPI_t)$. The data on nominal bilateral exchange rate with respect to the US dollar comes from IMF IFS.

For *nominal short-term interest rates* (r), we mainly rely on the 3-month or 90-day interbank interest rates from the OECD database. For the US, we use the 3-month treasury bill secondary market rate. Money market interest rates for Brazil, Chile and Georgia are taken from the IFS IMF. For other countries, we use deposit interest rate from the IFS (except Kazakhstan, where the data are taken from national sources).

For *foreign-specific variables*, we follow Feldkircher (2013) and use weighted foreign output (y^*) and interest rates (r^*) as weakly exogenous variables. The weights used to construct foreign output variables are based on annual bilateral goods trade flows (i.e. exports plus imports in US dollars). The trade data come from the IMF Direction of Trade Statistics database, which provides data on the geographical distribution of countries' exports and imports.

For construction of foreign interest rate variables, we use financial weights. The use of financial weights in GVAR models has recently gained popularity as they provide the information on how financial markets of different countries are linked with each other. In GVAR models, financial weights reduce the amplification of impulse responses; a common problem when only trade weights are used. Existing studies mostly rely on financial weights from the Bank of International Settlement (BIS) consolidated banking statistics.[11] They provide consolidated foreign claims of reporting banks on individual countries and represent the information on the degree of financial exposures of countries banking system. BIS statistics, however, only include data only for reporting banks and Russian Federation; CIS countries are not represented.

To incorporate financial exposures of CIS economies, we use the IMF's Coordinated Portfolio Investment Survey (CPIS), a dataset on the stock of cross-border holdings of equities and long- and short-term debt securities broken down by issuer residence. Although the BIS statistics and CPIS differ in their data collection methods, financial weight matrices at least seem to have a high correlation for BIS reporting countries. As with trade, we use time-varying weights for financial linkages. This approach allows us account for financial market trends in the CIS.

[11] See e.g. Galesi & Sgherri (2009) and Fedajeva et. al. (2014).

Global variables in GVAR models are commonly represented by *oil prices*. In our analysis, we use logarithms of seasonally adjusted Brent oil price indexed to the 2010 average. We model oil prices in a dominant unit univariate model, where we also include feedback variables on real output based on PPP-adjusted GDP weights. This helps incorporate the effect of each individual country on the dynamics of oil prices with respect to the country's size.

5.2. Model setup

Before setting up individual VECMX* models and combining them into a global model, we first run a set of statistical tests to explore data properties and ensure the suitability of our analytical framework.

To test for stationarity of variables, we run Augmented Dickey-Fuller (ADF) unit-root tests. Summary results for variables in levels and first differences are presented in Table 4 A and B, respectively. The results suggest that real output, real exchange rate and interest rate, as well as their foreign counterparts in levels, are integrated of first order for most countries. At the same time, the unit-root hypothesis for consumer inflation in levels can be rejected in most cases. Following existing studies on GVAR modeling and pursuing VECM econometric framework, we conclude that most time series are integrated of order one. This ensures the stationarity of the final GVAR model. In particular, 38 of the 209 time series are stationary in levels, while 183 of the 209 time series are stationary in first differences.

We next choose a lag length for domestic, foreign and global variables in each individual VECMX* model. Although the lag length is usually determined by minimizing AIC, we set the lag length for domestic, foreign as well as global variables equal to one in our analysis due to the relatively short dataset. We determine the rank of cointegration relationships according to Johansen's trace statistics[12] and the type of deterministic components using the likelihood ratio (LR) test[13]. Tables 5 and 6 present summary results for the choice of cointegration rank and the type of deterministic components. Individual VECMX* specifications are provided in Table 7.

We run a set of diagnostics tests to verify the final specifications of individual VECMX* models. Foreign variables are tested for weak exogeneity, which in the VECMX* framework implies no feedback from domestic variables to the foreign counterparts in the long run. Results for the test, presented in Table 8, suggest that the hypothesis of no weak exogeneity can be rejected for most countries, supporting the econometric approach used here. The F-test rejects the hypothesis of no weak exogeneity for 72 of 87 foreign variables at the 5 % significance level. In addition to weak exogeneity tests, we test each individual VECMX*

[12] See Pesaran, Shin and Smith (2000) for details.

[13] We distinguish three cases (Case II, III and IV in Table 6) of deterministic components in the cointegration relationship. See e.g. Pesaran, Shin and Smith (2000) and MacKinnon, Haug and Michelis (1999) for details.

models for residual serial correlation. As mentioned, a relatively short dataset limits the ability to include additional lags to deal with residual serial correlation. Following the F-test results (see Table 9), the hypothesis of first-order serial correlation can be rejected for 87 of 120 equations at the 5 % significance level.

Our final test examines the cross-country correlation of the residuals. Average pairwise cross-section correlations are presented in Table 10. Our results generally are quite similar to those of Feldkircher (2013). The cross-country correlations are low with the exception of the equation of the real exchange rate (correlations range from 0.2 to 0.4 for some countries).

To sum up, diagnostic tests carried out in the paper in general support the final setup of the GVAR model. Foreign specific counterparts of domestic variables in each individual model deal with cross-country residual correlation. Nevertheless, a relatively high number of individual country models with first order serial correlation of residuals limits the ability for structural interpretation of exogenous shocks.

6. Results

In this section, we compute generalized impulse response functions (GIRFs) to examine the propagation of foreign shocks across CIS economies. In particular, we explore the response of real activity in the CIS region to output shocks in the US, euro area, China, and Russian Federation, as well as CIS regional shocks. We also present GIRFs for an oil price shock, which, like for most countries (see Fernández et al., 2017), is potentially an important driver for the CIS region.

6.1. Results with time-invariant weights

As a baseline estimation, we first compute the GIRFs using trade and financial weights computed as averages over the entire time span of our analysis, 2001–16. Our baseline estimation is quite similar to those presented in the previous literature (Feldkircher, 2015; Feldkircher & Korhonen, 2014), making our results readily comparable to estimates obtained from earlier models.

6.1.1. Responses to output shocks

Figure 3 plots the response of real activity in the CIS region and in major economies to 1 % output shocks in corresponding economies with a perspective of 30 quarters.[14] The results are largely in line with the earlier literature (Feldkircher, 2015). A 1 % shock to output in the US results in an output increase of similar size in the CIS region, whereas the impact for the euro area and Russia is around 0.5 %. The response of Chinese output is near zero. Responses to an output shock originating in the euro area are more moderate. Following a 1 % euro area

[14] The response for the CIS region is calculated using PPP-adjusted GDP aggregation.

output shock, output of the CIS region increases by 0.5 % and output of Russia by 0.2 %. Somewhat surprisingly, the responses of US and Chinese output are tiny. This may reflect the fact that these countries are relatively less involved in foreign trade. Responses of all countries and regions to an output shock in China are also quite small (0–0.2 %), but the result is in line with estimates from the earlier literature (Feldkircher & Korhonen, 2014; Dreger & Zhang, 2014).

Figure 4 provides impulse responses of each individual CIS country. The strongest output responses in most individual CIS countries are caused by output shocks in the US and CIS region. The responses to a US shock vary from 0.4 % in Kazakhstan to nearly 2 % in Azerbaijan and correspondingly, between 0.4-1.5 % to a shock in the CIS region itself. A notable exception is, however, Belarus, where output reaction is the strongest by far to a shock originating from Russia, reaching over 2 %. This could be expected, however, as the Belarussian economy remains closely linked to the Russian economy in terms of both trade and financial linkages. The responses to a Chinese output shock are relatively moderate in most CIS countries, ranging from 0.1 % for Ukraine to 0.5 % for Azerbaijan. These results, too, are largely in line earlier studies (Feldkircher, 2015; Feldkircher & Korhonen, 2014).

6.1.2. Responses to an oil price shock

We now consider the output responses of our selected economies to an oil price shock; specifically, a 50 % increase in the oil price. The impulse responses are shown in Figure 5. The results are largely in line with previous research, both qualitatively and quantitatively (Feldkircher, 2015). The output response is somewhat negative for net oil importers such as the US (-0.4 %) and the euro area (-0.6 %), and clearly positive for an oil exporter like Russia (4 %).

The strongly positive response of the CIS region to an oil price shock is somewhat surprising, but may reflect several factors. Unlike in Feldkircher (2015), our CIS aggregate includes Azerbaijan and Kazakhstan, both substantial oil exporters. The positive response is also affected by Belarus, which, despite its lack of hydrocarbon resources, processes considerable amounts of Russian crude oil and then exports refined products. As suggested by Feldkircher (2015), the negative impact of an oil price increase for oil-importing Ukraine and Georgia may be overcome by the spillover effect from the positive impact on the Russian economy.

6.2. Results with time-varying weights

Up to this point, we have analyzed the sensitivity of CIS economies to foreign shocks using time-invariant trade composition and financial linkages. However, as discussed in section 3, the CIS region and the world economy in general over the last two decades have experienced considerable changes in trade and financial integration that could affect the transmission of international shocks.

Accounting for the changes in the composition of global trade and financial relations, we compute generalized impulse responses (at the 30th period) to the shocks using time-varying trade and financial weights for four periods: 2001–2004, 2005–2008, 2009–2012 and 2013–2016. We then examine the effects of a 1 % shock on output of the various regions and major economies, as well as a 50 % oil price shock. The results for the larger regions and economies are presented in Figure 6. Figure 7 displays the results for the individual CIS countries.

6.2.1. Responses to output shocks

As Figure 6 shows, the output responses of the CIS region to output shocks of various economies have changed substantially over the past two decades. The CIS output response to a shock from the euro area output increases steadily from about 0.1 % with the 2001–04 weights to 0.8 % with the 2013–16 weights.[15] Response to a shock in the CIS region itself has also intensified notably, in particular after the global financial crisis. Responses to output shocks in Russia and China have also increased slightly. Even with the latest weights, however, the response to Chinese shocks is quite moderate at about 0.2 %. In contrast, the response of the CIS output to a shock on US output has declined gradually from 1.2 % with the 2001–04 weights to 0.9 % with the 2013–16 weights.

Taken individually, the developments in CIS countries, as seen from Figure 7, are quite similar. The output response to a shock originating in the euro area increases steadily in all countries, ranging from 0.1 % for Azerbaijan to 1.5 % for Ukraine when using the latest weights. The sensitivity to the local output shocks in the CIS region also increases substantially after the global financial crisis in all individual CIS countries. The impact of US shocks declines, especially for Belarus, while the impact of Chinese shocks increases, particularly for Georgia and Ukraine (but still quite moderate at less than 0.5 %).

Figure 6 shows changes in output responses of other regions are much smaller than for the CIS region. The reactions of Russian output to shocks in the euro area and the CIS region increase a bit, reaching 0.5 % when estimated using the latest weights. For the US, euro area and China, changes over time are small. The growing role of China is reflected in the slightly increasing response of the euro area output to a Chinese output shock.

6.2.2. Decomposition of output shock responses

To better understand the reasons behind the changes in responses of the CIS countries, we decompose the changes to effects originating from direct and indirect trade and financial linkages by extending the approaches of Fadejeva et al. (2017) and Cesa-Bianchi et al. (2012).

[15] The enlargement of the euro area during the time period may affect the result as we include the changing composition of the euro area in our model. The effect should be fairly small, however. The additional euro area member countries combined only accounted for about 2 % of CIS region trade in 2016.

We compute GIRFs for the CIS countries using a number of time-specific counterfactual weights. In particular, we first compute GIRFs for the baseline period (2001–2004) and thereafter change, step by step, trade and financial weights for the CIS countries (direct effect) and other economies (indirect effect). Figure 8 decomposes the changes of responses of the CIS aggregate to direct trade, direct financial, indirect trade and indirect financial effects. The reinforcing effect refers to the residual that cannot be allocated to any particular effect. Figure 9 plots similar decomposition for individual CIS countries, although most of the effects are quite similar across countries. The results of the decomposition are slightly puzzling in several cases. This could be related to the brevity of the observation period, especially since it includes large fluctuations in the CIS economies.

Starting from the most notable change, the decomposition in Figure 8 suggests that the substantial increase in the response of the CIS countries to an output shock in the euro area comes mainly through the trade channel, particularly the indirect trade channel, while the contribution of the financial channels (both direct and indirect) is slightly negative. The result for the trade channel is slightly puzzling, given that the euro area's share of trade with CIS countries has increased slightly and declined for trade with the other regions. Our Rest of the World aggregate includes EU members and associates outside the euro area, e.g. the CEE countries, UK and Turkey. Moreover, the trade share of the euro area with these countries may have increased, even if its trade share has declined with other countries included in the Rest of the World aggregate (e.g. Japan and Korea). These countries are important trading partners for most CIS countries. Therefore, the impact of an output shock to the euro area for the CIS countries may have been magnified indirectly through increased trade integration between the euro area and the CEE countries. Fadejeva et al. (2017) point to a similar possibility in the case of Baltic countries. They find indirect effects contributing more than direct effects.

As Figure 8 shows, the growing sensitivity of the CIS countries to intra-regional shocks seems mainly related to increasing trade and financial linkages among the CIS countries. The effect is surprisingly strong, given the modest increase in their mutual trade shares and marginal increase in mutual financial linkages. However, the residual effect is quite large, especially in the latter half of the observation period. As expected, the contribution of the indirect trade effect is clearly negative as the trade share of the CIS countries for other regions was small to begin with and declines slightly.

The modest increase in the CIS response to a Chinese output shock is mainly due to indirect effects as expected. The direct role of China is still quite limited in trade and financial linkages with the CIS countries in our sample. This finding comports with the results of Cesa-Bianchi et al. (2012), who suggest that the impact of shocks originating in China on Latin American countries has increased largely due to the indirect channel. For the CIS economies, also in the case of an increased impact from a Russian output shock, the main contribution comes from the indirect financial effect. This could again be related to some countries in the Rest of the World bloc as the share of Russia has not increased in the financial linkages for any of the major economies. The residual effect is also quite large in the case of Russia.

We can see from Figure 8 that the sensitivity of the CIS countries has declined slightly only for output shocks originating in the US. This development, which seems mainly due to the direct financial effect, is quite baffling as the share of the US has increased in the financial linkages of the CIS region. On the other hand, the effect is relatively small and seems driven mainly by Azerbaijan as shown in Figure 9. In contrast, the indirect financial effect of a US shock on the CIS aggregate is almost as large and positive. This is quite in line with Fadejeva et al. (2017), who conclude that indirect effects dominate in the transmission of US shocks to CIS economies.

6.2.3. Responses to an oil price shock

As our final exercise, we apply the time-varying weights to the analysis of an oil price shock, aware that changes in the geographical composition of trade and financial linkages may alter the responses of economies to oil price shocks. This seems to be the case, but with slightly different implications for different regions as shown in Figure 10.

The responses of the US and the euro area output are negative for all different time weights, but the responses become slightly milder over time. For the euro area in particular, this may reflect the increasing spillover effects from China. Since an oil price shock has a positive effect on Chinese output, spillovers from China may mitigate the negative effect of an oil price shock for the euro area. In the US, the milder response could also relate to the increasing domestic oil production and declining dependence on oil imports.

On the other hand, the positive responses of the CIS countries and Russia to an oil price shock are somewhat strengthened when using the trade and financial weights for the later parts of the observation period. This may reflect the increased sensitivity of the CIS economies and Russia to each other’s shocks; the positive effect of an oil price shock reinforces spillover effects across the region. In addition, the role of oil increases e.g. in the Russian economy in the latter part of the observation period compared to the early years. The development of the responses to oil price shocks is fairly similar across the individual CIS countries, although distinctly pronounced for Belarus (probably because the country has such close linkages with the Russian economy).

7. Conclusions

This paper examined the sensitivity of the CIS economies to global and regional shocks with a global VAR model, concentrating particularly on output shocks originating in select major economies and oil price shocks. Complementing previous literature, we considered in detail changes over time in the output responses of the CIS economies by applying time-varying trade and financial weights. We also investigated separately the significance of shocks originating in Russia for the CIS economies. In addition, we have decomposed the changes in responses of CIS countries to direct and indirect trade and financial effects to better understand the origins of the changes.

Our results show that the CIS region continues to be highly sensitive to both regional and global shocks. Throughout our two-decade observation period, CIS responses were strongest to output shocks originating within the region itself, or in Russia and the US. These responses are all roughly of similar magnitude. The CIS region also responds strongly to oil price shocks. Notably, the response is positive across the individual countries, even if they are not net exporters of oil. This reflects the importance of the spillover effects within the CIS region and from Russia.

The sensitivity of the CIS economies to regional and global shocks has increased in past decades, particularly since the global financial crisis. The increase in sensitivity has been most pronounced for shocks originating within the region and shocks coming from the euro area. The increased impact of regional shocks is mainly due to direct trade and financial channels as the CIS economies have integrated extensively with the global economy. For euro area shocks, the main channel contributing to stronger CIS responses seems to be the indirect trade effect. This is slightly puzzling, but could be due to transmission effects through the CEE countries outside the euro area.

Despite some decrease in trade and financial linkages between the CIS region and Russia in past years, the sensitivity of the CIS countries to Russian shocks has not decreased. On the other hand, despite the increase in economic linkages between the CIS countries and China, the output responses of the CIS economies to shocks originating in China still seem to be quite small even when indirect effects are considered.

Our results suggest that the CIS countries need to pay close attention to global and regional economic developments in their policy planning. They are relatively small countries with minor influence over global developments. Thus, the policy challenge is preparedness. The implementing of prudent policies and creation of adequate buffers can help CIS countries deal with potential shocks at the regional level and from global markets.

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Tables

Table 1. Real GDP cross-country correlations (annual growth rates)

Pre-crisis 2001–2008	USA	EA	CHINA	RUSSIA	CIS
USA	1	0.36	0.28	0.52	0.14
EA	-	1	0.66	0.66	0.17
CHINA	-	-	1	0.85	0.19
RUSSIA	-	-	-	1	0.25
CIS	-	-	-	-	0.08*
Post-crisis 2009–2016	**USA**	**EA**	**CHINA**	**RUSSIA**	**CIS**
USA	1	0.87	-0.31	0.70	0.30
EA	-	1	-0.20	0.61	0.25
CHINA	-	-	1	0.22	0.30
RUSSIA	-	-	-	1	0.58
CIS	-	-	-	-	0.41*

* shows average cross-country correlations within CIS economies

Source: World Bank Open Data – World Development Indicators

Table 2. Description of the GVAR model main features and variables

Time coverage	2001Q1 - Q2016Q4
Countries and regions	US China Russia Euro area (block with 12–19 countries): Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain (2001–2006); *plus* Slovenia (2007), Cyprus, Malta (2008), Slovakia (2009), Estonia (2011), Latvia (2014), Lithuania (2015) CIS (5 countries): Azerbaijan, Belarus, Georgia, Kazakhstan, Ukraine Rest of the World (23 separate countries): Australia, Brazil, Bulgaria, Canada, Chile, Czech Rep., Denmark, Hungary, Iceland, India, Indonesia, Japan, Korea, Mexico, New Zealand, Norway, Poland, Romania, Sweden, Turkey, UK
Variables	***y*** = real GDP, index (average of 2010=100), seasonally adjusted, in logs ***dp*** = consumer price inflation, seasonally adjusted, first log-differences ***e*** = real exchange rate (nominal exchange rate w.r.t USD deflated by domestic CPI), index (average of 2010=100), in logs ***r*** = nominal short-term interest rate, typically 3-month or 90-day interbank interest rate ***f*** = Brent oil price, index (average of 2010=100), seasonally adjusted, in logs
Weights	Trade: shares of partner countries in total goods trade (sum of exports and imports) Financial: shares of partner countries in the stock of cross-border holdings of equities and long- and short-term debt securities

Table 3 (A). Country data descriptive statistics

Country	Real GDP				Inflation,%			
	Min	Mean	Max	SD	Min	Mean	Max	SD
USA	4.46	4.61	4.75	0.08	-2.18	0.51	1.41	0.56
EMU	4.35	4.58	4.75	0.11	-0.39	0.42	1.19	0.33
CHN	3.65	4.41	5.07	0.44	-1.1	0.58	2.57	0.67
RUS	4.16	4.54	4.73	0.18	0.35	2.5	6.98	1.13
AZE	3.57	4.49	4.97	0.50	-2.68	1.62	7.75	1.94
BLR	3.67	4.44	4.95	0.43	0.52	4.84	24.04	4.5
GEO	4.18	4.68	5.03	0.26	-4.35	1.14	4.64	1.56
KAZ	3.94	4.54	4.92	0.29	0.32	1.98	8.31	1.32
UKR	4.24	4.55	4.75	0.13	-1.68	2.78	19.64	3.23
AUS	4.32	4.57	4.78	0.13	0.03	0.64	1.43	0.35
BRA	4.27	4.53	4.73	0.15	0.53	1.64	5.59	0.82
BGR	4.20	4.54	4.75	0.16	-0.77	0.92	5.47	1.21
CAN	4.45	4.61	4.75	0.09	-1.07	0.45	1.4	0.45
CHL	4.26	4.59	4.86	0.19	-2.13	0.78	2.56	0.73
CZE	4.33	4.56	4.73	0.12	-0.41	0.5	2.76	0.57
DNK	4.54	4.62	4.70	0.04	-0.09	0.41	1.35	0.31
HUN	4.44	4.62	4.74	0.07	-0.62	0.98	2.66	0.8
ISL	4.35	4.60	4.85	0.12	-0.19	1.22	5.34	1.06
IND	3.94	4.51	5.06	0.34	-0.11	1.64	4.84	0.94
IDN	4.14	4.55	4.96	0.25	-0.03	1.74	9.33	1.31
JPN	4.55	4.62	4.68	0.04	-0.93	0.02	2.01	0.42
KOR	4.21	4.55	4.81	0.17	-0.04	0.64	1.85	0.39
MEX	4.42	4.61	4.79	0.11	0.29	1.01	1.7	0.34
NZL	4.33	4.57	4.77	0.11	-0.19	0.52	2.8	0.47
NOR	4.45	4.58	4.69	0.07	-1.9	0.49	2.62	0.61
POL	4.26	4.55	4.82	0.18	-0.66	0.51	1.63	0.55
ROU	4.22	4.56	4.79	0.16	-1.65	1.79	7.86	1.84
SWE	4.44	4.61	4.78	0.09	-0.9	0.3	1.38	0.43
TUR	4.16	4.62	5.03	0.25	0.54	3.16	19.43	3.18
GBR	4.48	4.62	4.74	0.07	-0.3	0.51	1.75	0.39

Table 3 (B). Country data descriptive statistics

Country	Real exchange rate				Interest rate,%			
	Min	Mean	Max	SD	Min	Mean	Max	SD
USA	-	-	-	-	0.01	1.37	4.98	1.65
EMU	4.46	4.68	4.99	0.13	-0.33	1.88	4.98	1.63
CHN	4.45	4.66	4.84	0.15	1.50	2.53	4.14	0.69
RUS	4.48	4.83	5.38	0.27	3.37	5.59	11.57	1.64
AZE	4.53	4.88	5.29	0.30	5.35	9.97	12.54	1.52
BLR	4.41	4.75	5.18	0.18	6.97	15.86	42.43	7.96
GEO	4.40	4.74	5.13	0.22	3.46	9.61	30.33	6.45
KAZ	4.49	4.78	5.14	0.23	3.77	7.35	13.00	2.21
UKR	4.35	4.76	5.23	0.22	6.43	10.03	17.11	2.56
AUS	4.46	4.77	5.24	0.22	1.76	4.48	7.80	1.54
BRA	4.49	4.92	5.57	0.28	7.13	13.84	26.24	4.38
BGR	4.50	4.78	5.33	0.23	0.11	2.98	6.49	1.40
CAN	4.55	4.74	5.00	0.14	0.38	2.16	5.14	1.37
CHL	4.51	4.72	5.03	0.14	0.43	4.04	8.99	1.81
CZE	4.44	4.79	5.32	0.22	0.29	1.99	5.41	1.43
DNK	4.47	4.68	4.99	0.13	-0.20	2.13	5.81	1.74
HUN	4.42	4.74	5.21	0.19	0.31	6.54	12.44	3.18
ISL	4.16	4.49	4.74	0.16	4.00	8.55	17.96	3.72
IND	4.54	4.77	5.02	0.15	8.00	11.12	13.75	1.20
IDN	4.54	4.80	5.34	0.18	5.66	8.98	17.22	3.04
JPN	4.54	4.73	5.00	0.12	0.03	0.38	1.05	0.24
KOR	4.43	4.59	4.82	0.10	1.35	3.59	5.95	1.24
MEX	4.45	4.61	4.94	0.10	3.30	6.64	18.15	2.77
NZL	4.45	4.69	5.19	0.20	2.08	4.82	8.83	2.14
NOR	4.49	4.70	4.98	0.14	0.99	3.29	7.45	1.99
POL	4.34	4.71	4.95	0.15	1.68	5.22	18.17	3.32
ROU	4.42	4.73	5.16	0.21	0.98	8.61	28.90	6.62
SWE	4.43	4.64	4.90	0.13	-0.78	1.81	4.41	1.55
TUR	4.51	4.84	5.44	0.23	12.13	25.01	87.36	16.34
GBR	4.37	4.55	4.81	0.09	0.38	2.74	6.31	2.13
	Global variables							
	Min	Mean	Max	SD				
Brent	3.65	4.69	5.41	0.50				

Note. ADF tests for inflation and interest rate include constant term (Fcrit. 0.05 = -2.89), while tests for output, real exchange rate, and fuel prices include constant as well as trend term (Fcrit. 0.05 = -3.45).

Table 4 (A). ADF unit-root test

	USA	EMU	CHN	RUS	AZE	BLR	No. < CV
y	-2.24	-2.22	0.24	-1.53	-1.53	-0.03	0
dp	-5.19	-3.39	-4.58	-3.91	-3.49	-2.60	5
e	0.00	-0.98	-1.28	-0.76	-1.29	-1.29	0
r	-2.02	-1.94	-2.01	-2.65	-0.87	-2.56	0
y*	-3.34	-3.07	-2.60	-2.28	-2.20	-1.89	0
r*	-1.13	-1.23	-1.36	-1.13	-2.07	-1.06	0
f	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	0
	GEO	KAZ	UKR	AUS	BRA	BGR	No. < CV
y	-1.95	-0.75	-1.86	-2.11	0.68	-1.91	0
dp	-4.39	-4.60	-3.16	-5.17	-2.15	-3.02	5
e	-0.36	1.43	-0.89	-1.86	-1.74	-0.04	0
r	-2.32	-2.45	-2.99	-0.74	-1.55	-0.70	1
y*	-1.72	-1.52	-2.35	-2.10	-3.10	-2.36	0
r*	-1.35	-1.33	-1.84	-1.35	-1.37	-1.09	0
f	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	0
	CAN	CHL	CZE	DNK	HUN	ISL	No. < CV
y	-2.68	-1.08	-1.95	-2.09	-2.07	-1.58	0
dp	-6.91	-4.04	-4.00	-3.63	-3.81	-3.16	6
e	-1.09	-1.66	-0.39	-0.93	-1.23	-3.36	0
r	-1.28	-4.01	-2.91	-1.73	-1.35	-2.00	2
y*	-2.24	-3.70	-2.29	-2.58	-2.31	-2.51	1
r*	-1.57	-1.31	-1.81	-1.19	-1.20	-1.21	0
f	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	0
	IND	IDN	JPN	KOR	MEX	NZL	No. < CV
y	-2.10	-1.74	-2.82	-2.65	-3.10	-2.97	0
dp	-1.41	-4.28	-4.42	-3.70	-3.02	-4.25	5
e	-1.19	-2.00	-1.66	-2.59	-1.45	-2.70	0
r	-1.93	-4.19	-2.54	-1.17	-2.56	-1.17	1
y*	-4.20	-2.65	-4.23	-4.06	-2.18	-2.35	3
r*	-1.23	-1.21	-1.22	-1.40	-1.50	-1.23	0
f	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	0
	NOR	POL	ROU	SWE	TUR	GBR	No. < CV
y	-1.59	-2.24	-1.92	-3.45	-2.58	-2.02	0
dp	-6.20	-3.42	-3.60	-4.31	-4.55	-2.92	6
e	-0.79	-0.49	-0.87	-1.66	-0.72	-1.66	0
r	-2.78	-4.34	-3.17	-1.24	-4.75	-1.45	3
y*	-2.67	-2.40	-2.39	-2.58	-2.64	-2.47	0
r*	-1.26	-1.73	-1.90	-1.14	-1.22	-1.21	0
f	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	0

Note. ADF tests for inflation and interest rate include constant term (Fcrit. 0.05 = -2.89), while tests for output, real exchange rate, and fuel prices include constant as well as trend term (Fcrit. 0.05 = -3.45).

Table 4 (B). ADF unit-root test

	USA	EMU	CHN	RUS	AZE	BLR	No. < CV
dy	-3.96	-3.16	-6.12	-3.42	-1.17	-4.93	5
ddp	-6.64	-7.49	-6.20	-7.93	-6.01	-6.77	6
de	-	-3.36	-2.04	-4.87	-1.81	-4.10	3
dr	-2.65	-3.50	-4.29	-5.18	-6.29	-4.14	5
dy*	-3.99	-4.29	-4.65	-5.47	-4.44	-3.56	6
dr*	-3.53	-2.35	-2.27	-2.43	-4.31	-5.48	3
df	-5.59	-5.59	-5.59	-5.59	-5.59	-5.59	6
	GEO	KAZ	UKR	AUS	BRA	BGR	No. < CV
dy	-3.63	-3.02	-4.16	-5.01	-4.45	-2.39	5
ddp	-7.07	-7.01	-5.67	-6.24	-6.74	-6.20	6
de	-4.21	-4.73	-4.52	-5.19	-5.15	-4.72	6
dr	-6.06	-7.02	-7.20	-5.14	-4.37	-3.70	6
dy*	-3.29	-3.70	-3.29	-3.85	-4.00	-3.67	6
dr*	-3.22	-2.20	-3.61	-2.22	-2.15	-2.98	3
df	-5.59	-5.59	-5.59	-5.59	-5.59	-5.59	6
	CAN	CHL	CZE	DNK	HUN	ISL	No. < CV
dy	-4.90	-4.61	-3.14	-4.03	-3.76	-2.21	5
ddp	-7.57	-6.21	-5.19	-8.39	-6.63	-5.44	6
de	-4.70	-5.35	-5.64	-3.43	-5.83	-4.32	6
dr	-3.68	-3.94	-3.15	-4.09	-4.60	-4.90	6
dy*	-4.33	-3.64	-3.42	-3.23	-3.62	-3.55	6
dr*	-2.15	-2.30	-3.22	-2.72	-3.25	-3.12	3
df	-5.59	-5.59	-5.59	-5.59	-5.59	-5.59	6
	IND	IDN	JPN	KOR	MEX	NZL	No. < CV
dy	-5.15	-5.53	-4.86	-4.86	-4.95	-4.99	6
ddp	-7.77	-6.14	-9.28	-8.58	-12.02	-6.36	6
de	-5.34	-3.98	-4.39	-4.69	-5.36	-4.69	6
dr	-5.97	-3.78	-2.67	-5.69	-5.48	-3.67	5
dy*	-4.21	-4.99	-3.48	-3.96	-4.62	-3.80	6
dr*	-2.26	-2.26	-2.32	-2.24	-2.15	-2.68	0
df	-5.59	-5.59	-5.59	-5.59	-5.59	-5.59	6
	NOR	POL	ROU	SWE	TUR	GBR	No. < CV
dy	-7.95	-2.70	-3.97	-4.26	-3.27	-4.07	5
ddp	-6.15	-7.58	-4.01	-8.40	-7.24	-6.55	6
de	-5.18	-6.15	-5.12	-5.37	-3.15	-5.35	6
dr	-4.26	-4.65	-4.06	-3.90	-5.00	-3.44	6
dy*	-3.43	-3.57	-3.48	-3.34	-3.86	-3.54	6
dr*	-2.53	-3.17	-3.38	-2.90	-2.86	-2.38	3
df	-5.59	-5.59	-5.59	-5.59	-5.59	-5.59	6

Note. ADF test for variables in first differences include a constant term only (Fcrit. 0.05 = -2.89).

Table 5. Trace statistics for testing the cointegration rank

Country	H0: r=0 H1: r≥1	H0: r=1 H1: r≥2	H0: r=2 H1: r≥3	H0: r=3 H1: r≥4	Selected rank
USA	164.48	80.89	17.89*	-	2
EMU	179.23	94.58	42.41	10.15*	3
CHN	202.03	82.25	38.19*	11.87	2
RUS	122.19	63.42*	35.57	11.77	1
AZE	172.17	103.3	49.84	9.300*	3
BLR	129.33	72.33	37.07*	13.51	2
GEO	146.72	87.07	45.16	11.30*	3
KAZ	153.95	94.73	53.04	20.17*	3
UKR	115.95	61.67*	30.71	13.48	1
AUS	116.69	51.78*	25.29	8.370	1
BRA	175.27	102.8	51.92	14.91*	3
BGR	148.41	93.78	49.37	14.60*	3
CAN	168.85	69.24	24.87*	10.41	2
CHL	145.24	76.64	31.20*	12.92	2
CZE	133.32	58.46*	26.65	7.280	1
DNK	121.70	73.83	33.56*	14.05	2
HUN	117.47	63.38*	33.83	10.67	1
ISL	166.55	91.29	42.22	11.45*	3
IND	122.32	61.62*	35.36	15.16	1
IDN	191.92	92.89	47.95	18.32*	3
JPN	106.32	42.40*	20.02	3.170	1
KOR	144.00	76.49	38.21*	10.40	2
MEX	152.48	89.75	33.72*	12.77	2
NZL	200.74	122.5	54.99	25.87	3
NOR	154.99	91.59	48.39	12.74*	3
POL	175.94	70.55	28.71*	10.22	2
ROU	115.79	69.65	36.07*	10.80	2
SWE	134.09	68.37	40.43*	15.47	2
TUR	236.94	125.7	39.21*	15.94	2
GBR	117.54	55.39*	25.82	8.630	1

Note. Critical values for null hypotheses r=1,2,3,4 are (91.81), (64.54), (41.03), and (20.98) respectively.

Table 6. Likelihood ratio test on type of deterministic components in the cointegration equations

Country	H0: Case III H1: Case IV		H0: Case II H1: Case III		Selected case
	LR	CV	LR	CV	
USA	10.6	(5.99)	7.78	(9.49)	IV
EMU	27.5	(7.82)	1.48	(9.49)	IV
CHN	12.7	(5.99)	25.1	(11.1)	IV
RUS	0.05	(3.84)	6.68	(12.6)	II
AZE	41.9	(7.82)	4.48	(9.49)	IV
BLR	0.90	(5.99)	1.00	(11.1)	II
GEO	22.3	(7.82)	2.36	(9.49)	IV
KAZ	27.4	(7.82)	11.7	(9.49)	IV
UKR	4.49	(3.84)	10.5	(12.6)	IV
AUS	1.43	(3.84)	36.4	(12.6)	III
BRA	13.6	(7.82)	0.02	(9.49)	IV
BGR	6.84	(7.82)	1.63	(9.49)	IV
CAN	3.21	(5.99)	1.53	(11.1)	II
CHL	15.5	(5.99)	15.9	(11.1)	IV
CZE	8.01	(3.84)	2.82	(12.6)	IV
DNK	6.44	(5.99)	1.01	(11.1)	IV
HUN	0.06	(3.84)	3.38	(12.6)	II
ISL	0.03	(7.82)	2.07	(9.49)	II
IND	9.53	(3.84)	26.7	(12.6)	IV
IDN	1.52	(7.82)	18.4	(9.49)	III
JPN	4.27	(3.84)	0.30	(12.6)	IV
KOR	9.12	(5.99)	14.4	(11.1)	IV
MEX	15.0	(5.99)	5.87	(11.1)	IV
NZL	41.5	(7.82)	10.1	(9.49)	IV
NOR	6.27	(7.82)	2.24	(9.49)	II
POL	14.7	(5.99)	7.62	(11.1)	IV
ROU	0.16	(5.99)	0.03	(11.1)	II
SWE	3.63	(5.99)	1.90	(11.1)	II
TUR	2.82	(5.99)	3.40	(11.1)	II
GBR	0.07	(3.84)	16.3	(12.6)	III

Table 7. Final individual VECMX* specifications

Country	Domestic	p	Foreign	q	r	Case
USA	y, dp, r	1	y*, r*, f*	1	1	IV
EMU	y, dp, e, r	1	y*, r*, f*	1	1	IV
CHN	y, dp, e, r	1	y*, r*, f*	1	1	IV
RUS	y, dp, e, r	1	y*, r*, f*	1	1	II
AZE	y, dp, e, r	1	y*, r*, f*	1	2	IV
BLR	y, dp, e, r	1	y*, r*, f*	1	2	II
GEO	y, dp, e, r	1	y*, r*, f*	1	2	IV
KAZ	y, dp, e, r	1	y*, r*, f*	1	2	IV
UKR	y, dp, e, r	1	y*, r*, f*	1	1	IV
AUS	y, dp, e, r	1	y*, r*, f*	1	1	III
BRA	y, dp, e, r	1	y*, r*, f*	1	1	IV
BGR	y, dp, e, r	1	y*, r*, f*	1	0	IV
CAN	y, dp, e, r	1	y*, r*, f*	1	2	II
CHL	y, dp, e, r	1	y*, r*, f*	1	1	IV
CZE	y, dp, e, r	1	y*, r*, f*	1	1	IV
DNK	y, dp, e, r	1	y*, r*, f*	1	2	IV
HUN	y, dp, e, r	1	y*, r*, f*	1	1	II
ISL	y, dp, e, r	1	y*, r*, f*	1	2	II
IND	y, dp, e, r	1	y*, r*, f*	1	1	IV
IDN	y, dp, e, r	1	y*, r*, f*	1	2	III
JPN	y, dp, e, r	1	y*, r*, f*	1	1	IV
KOR	y, dp, e, r	1	y*, r*, f*	1	2	IV
MEX	y, dp, e, r	1	y*, r*, f*	1	2	IV
NZL	y, dp, e, r	1	y*, r*, f*	1	1	IV
NOR	y, dp, e, r	1	y*, r*, f*	1	1	II
POL	y, dp, e, r	1	y*, r*, f*	1	2	IV
ROU	y, dp, e, r	1	y*, r*, f*	1	1	II
SWE	y, dp, e, r	1	y*, r*, f*	1	1	II
TUR	y, dp, e, r	1	y*, r*, f*	1	2	II
GBR	y, dp, e, r	1	y*, r*, f*	1	1	III

Table 8. Test for serial correlation of the VECMX residuals

Country	Fcrit. 0.05	y	p	e	r
USA	(2.54)	1.06*	1.95*	-	5.05
EMU	(2.54)	3.35	1.24*	2.33*	3.36
CHN	(2.54)	1.57*	3.85	0.71*	1.19*
RUS	(2.54)	1.18*	1.70*	2.02*	2.07*
AZE	(2.55)	3.28	4.68	4.09	1.16*
BLR	(2.54)	2.16*	3.61	2.66	5.86
GEO	(2.55)	1.82*	2.55	2.29*	1.33*
KAZ	(2.55)	2.41*	1.16*	4.13	2.58
UKR	(2.54)	0.19*	0.86*	2.43*	1.29*
AUS	(2.54)	0.64*	1.92*	0.45*	2.63
BRA	(2.54)	1.50*	4.00	3.02	7.60
BGR	(2.54)	4.11	5.13	1.90*	3.12
CAN	(2.54)	0.51*	0.60*	1.60*	2.57
CHL	(2.54)	1.82*	2.89	0.26*	0.11*
CZE	(2.54)	3.31	1.14*	0.94*	1.14*
DNK	(2.55)	0.97*	0.39*	2.84	0.28*
HUN	(2.54)	1.27*	1.21*	0.87*	1.95*
ISL	(2.54)	0.87*	0.75*	1.90*	1.24*
IND	(2.54)	0.68*	3.36	2.07*	2.39*
IDN	(2.55)	1.04*	1.10*	0.41*	1.59*
JPN	(2.54)	0.84*	2.16*	2.32*	2.99
KOR	(2.55)	1.24*	1.47*	1.06*	0.51*
MEX	(2.55)	1.87*	2.41*	0.43*	2.19*
NZL	(2.54)	0.77*	2.65	1.18*	1.85*
NOR	(2.54)	5.82	0.96*	0.55*	7.21
POL	(2.55)	2.12*	0.44*	1.60*	1.18*
ROU	(2.54)	1.55*	1.65*	1.79*	2.58
SWE	(2.54)	1.14*	1.58*	3.39	1.79*
TUR	(2.54)	2.08*	4.15	0.71*	0.87*
GBR	(2.54)	1.52*	0.14*	2.07*	5.22

Table 9. Test for weak exogeneity of foreign-specific variables

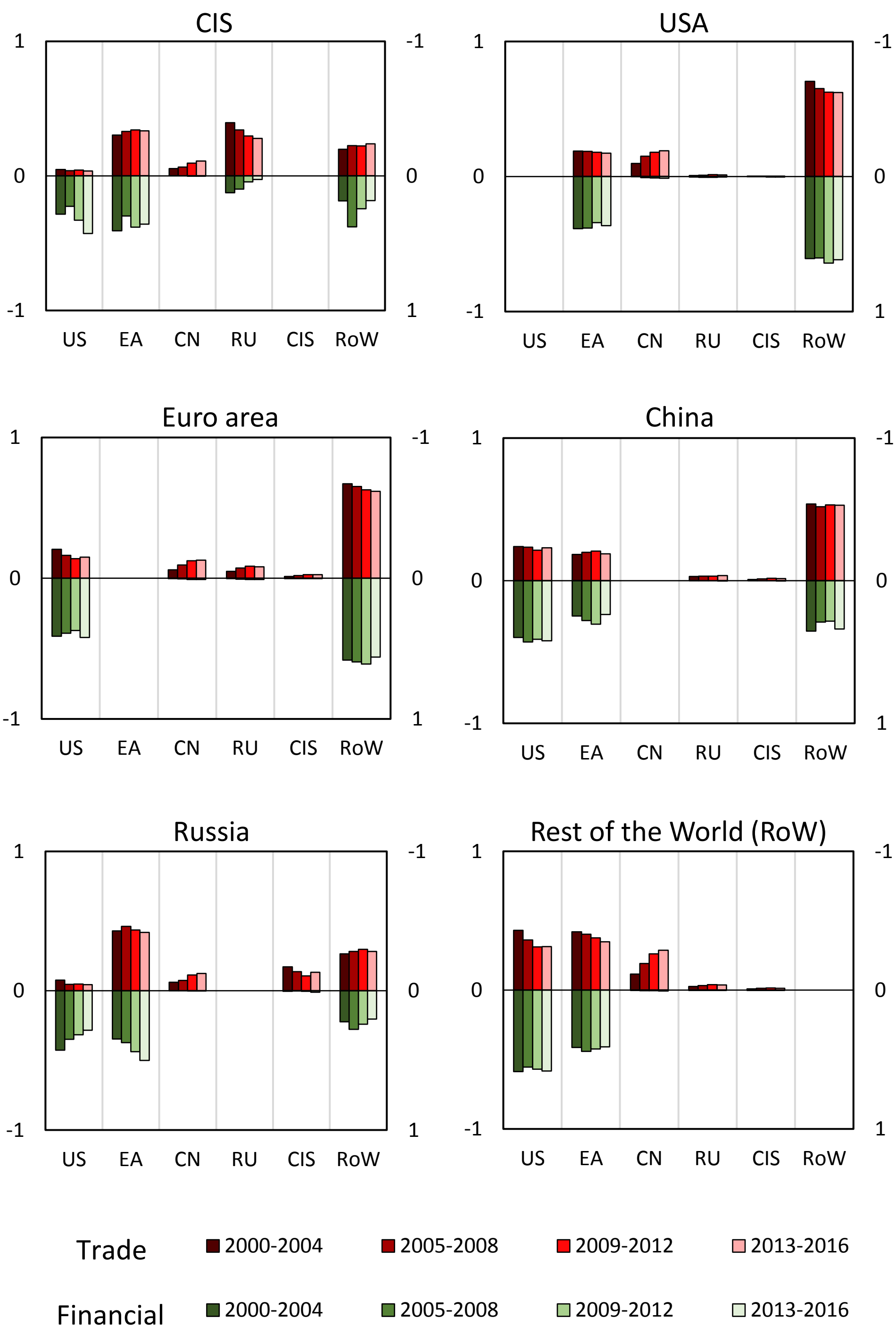
Country	Fcrit. 0.05	y*	r*	f
USA	(4.02)	2.79*	1.39*	3.76*
EMU	(4.02)	0.59*	1.17*	1.43*
CHN	(4.02)	6.11	4.76	1.05*
RUS	(4.02)	0.03*	0.72*	5.63
AZE	(3.18)	1.49*	1.14*	2.11*
BLR	(3.18)	1.08*	0.60*	0.71*
GEO	(3.18)	1.62*	0.73*	0.45*
KAZ	(3.18)	0.32*	0.07*	1.06*
UKR	(4.02)	0.00*	0.40*	1.07*
AUS	(4.02)	2.74*	0.61*	0.24*
BRA	(4.02)	0.07*	4.11	1.44*
BGR	-	-	-	-
CAN	(3.18)	4.78	3.65	3.76
CHL	(4.02)	0.87*	1.66*	0.86*
CZE	(4.02)	0.02*	1.43*	0.00*
DNK	(3.18)	0.51*	0.01*	0.98*
HUN	(4.02)	0.00*	0.03*	0.62*
ISL	(3.18)	4.06	2.10*	1.01*
IND	(4.02)	0.19*	0.25*	0.14*
IDN	(3.18)	0.16*	1.10*	2.87*
JPN	(4.02)	0.15*	0.53*	0.67*
KOR	(3.18)	3.46	1.30*	0.58*
MEX	(3.18)	2.30*	3.39	2.56*
NZL	(4.02)	2.36*	0.54*	1.11*
NOR	(4.02)	0.65*	2.17*	8.17
POL	(3.18)	1.67*	3.57	1.42*
ROU	(4.02)	0.20*	0.02*	0.65*
SWE	(4.02)	7.52	4.39	4.43
TUR	(3.18)	1.14*	1.10*	1.20*
GBR	(4.02)	3.98*	0.32*	0.39*

Table 10. Average pairwise cross-section residual correlations

Country	y	dp	e	r
USA	0.068	0.120	-	-0.128
EMU	0.095	0.162	0.448	0.109
CHN	-0.051	0.013	0.037	-0.055
RUS	0.067	0.040	0.151	-0.014
AZE	0.009	0.061	0.020	0.006
BLR	-0.024	0.041	0.101	0.039
GEO	-0.014	0.074	0.189	0.006
KAZ	0.050	0.078	-0.083	0.016
UKR	0.044	0.066	0.060	0.013
AUS	0.038	0.062	0.439	-0.043
BRA	0.043	0.085	0.277	0.001
BGR	0.030	-0.015	0.456	0.027
CAN	0.014	0.123	0.384	0.019
CHL	0.082	0.078	0.272	0.041
CZE	0.050	0.041	0.413	0.031
DNK	0.010	0.154	0.450	0.047
HUN	0.073	0.078	0.418	-0.020
ISL	0.031	0.076	0.206	0.020
IND	0.007	0.047	0.286	0.032
IDN	-0.020	0.027	0.209	0.038
JPN	0.060	0.036	0.090	-0.066
KOR	0.070	0.122	0.315	0.056
MEX	0.079	0.000	0.237	0.013
NZL	0.089	0.095	0.389	0.016
NOR	-0.005	0.134	0.406	0.079
POL	-0.022	0.118	0.344	0.027
ROU	0.054	0.026	0.434	0.006
SWE	0.017	0.222	0.452	0.026
TUR	0.006	0.098	0.275	0.042
GBR	0.030	0.168	0.351	0.045

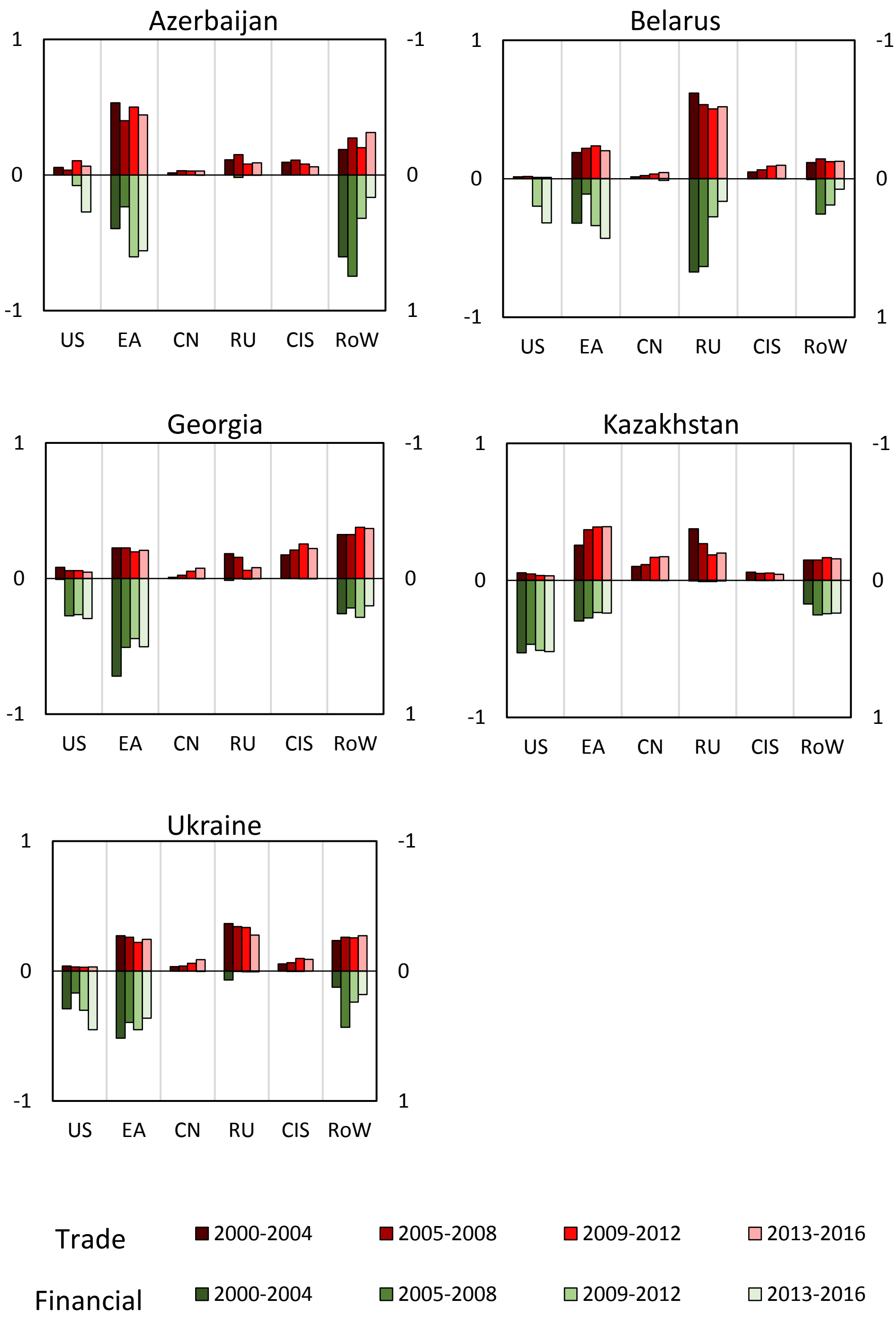
Figures

Figure 1. Evolution of trade and financial linkages in the world economy.



Note. The red bars depict trade shares by partners in different time periods summing up to 1 in each period, whereas the green bars give the corresponding development for financial linkages.

Figure 2. Evolution of trade and financial linkages in CIS economies.



Note. The red bars depict trade shares by partners in different time periods summing up to 1 in each period, whereas the green bars give the corresponding development for financial linkages.

Figure 3. Generalized Impulse Responses of real activity in major economies to 1% output shocks in the US, euro area, China, Russia and CIS (affected region in the heading, shock origins depicted by lines).

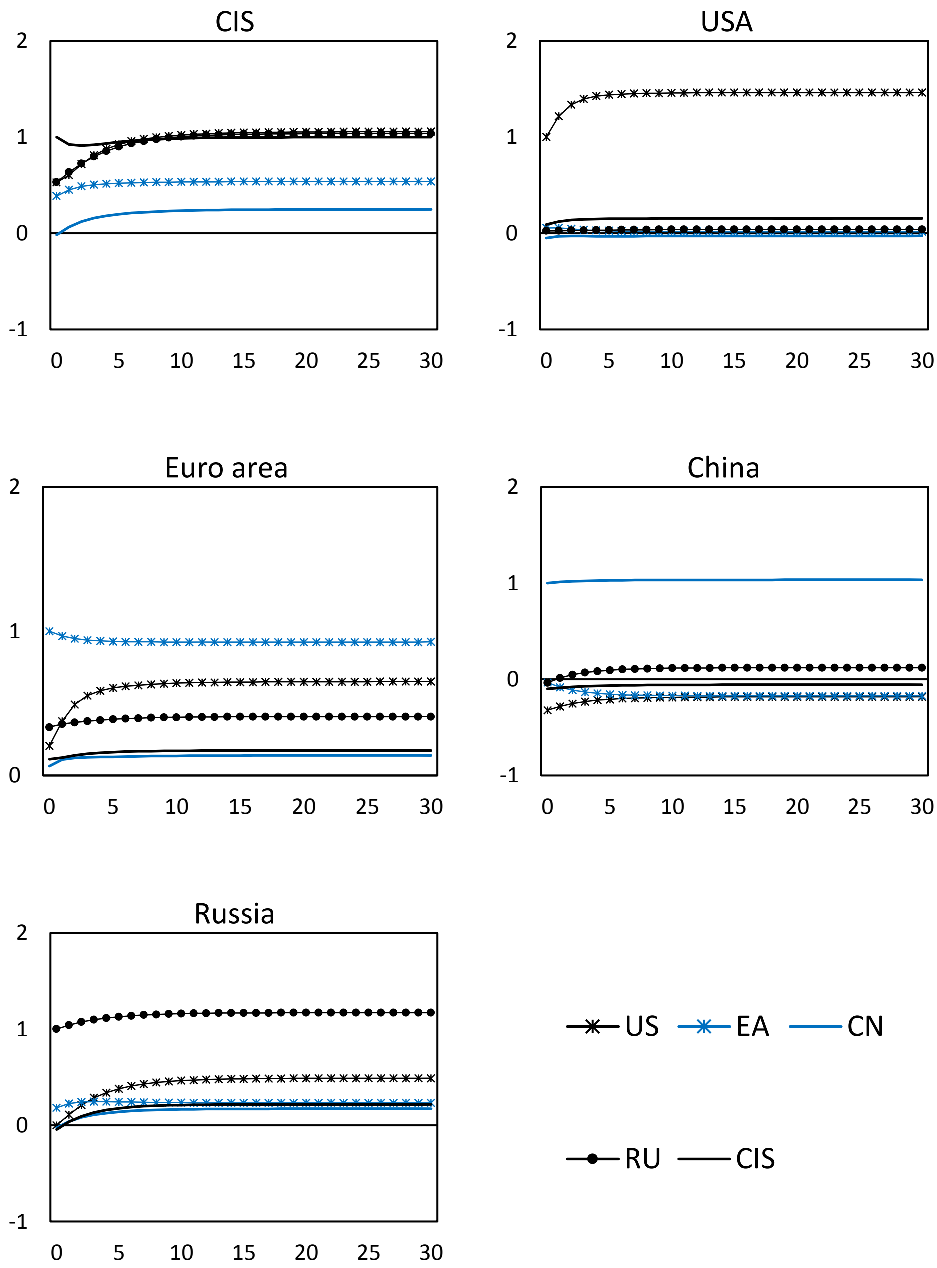


Figure 4. Generalized Impulse Responses of real activity in individual CIS countries to 1 % output shocks in the US, euro area, China, Russia and CIS (affected region in the heading, shock origins depicted by lines).

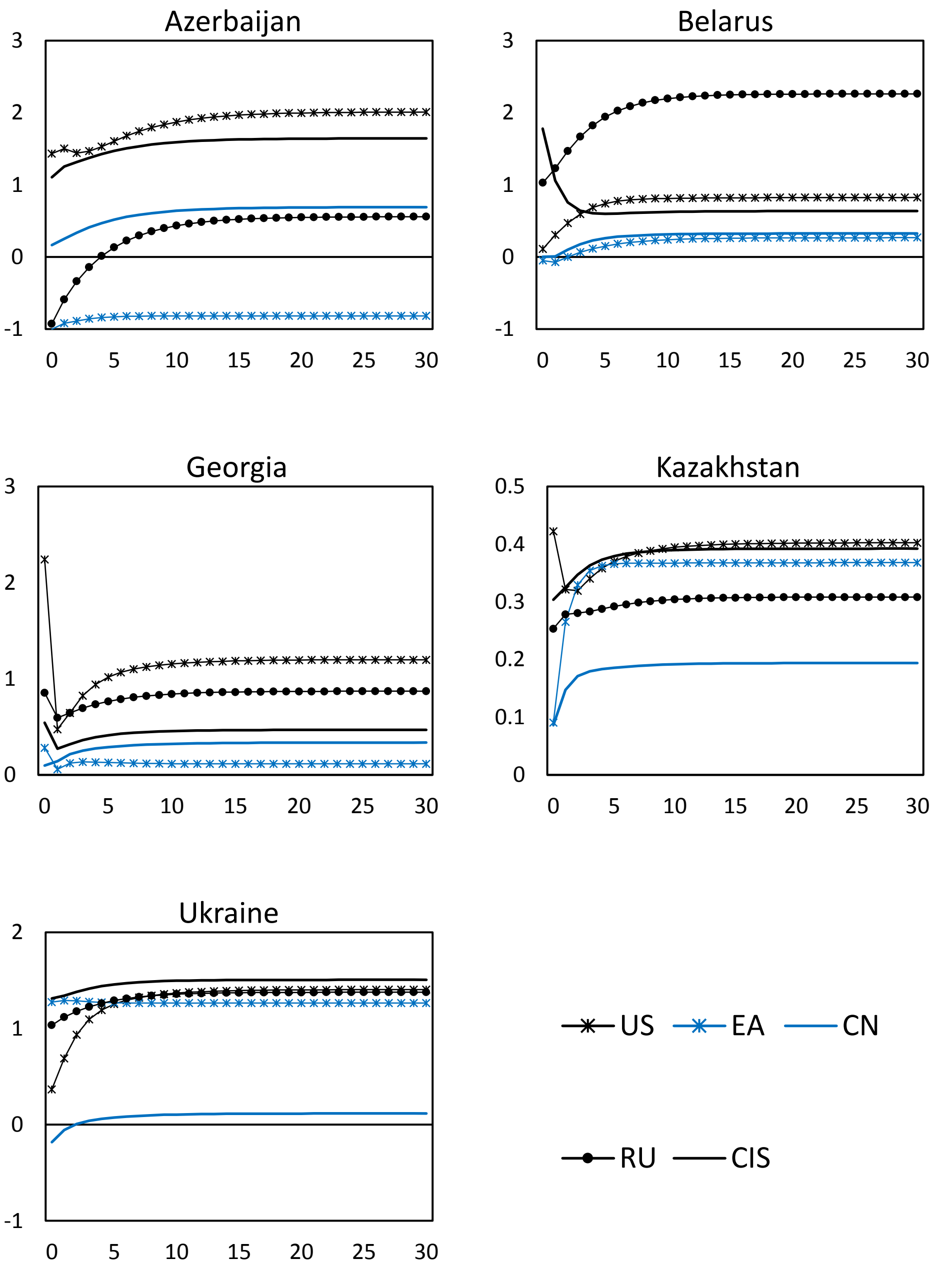
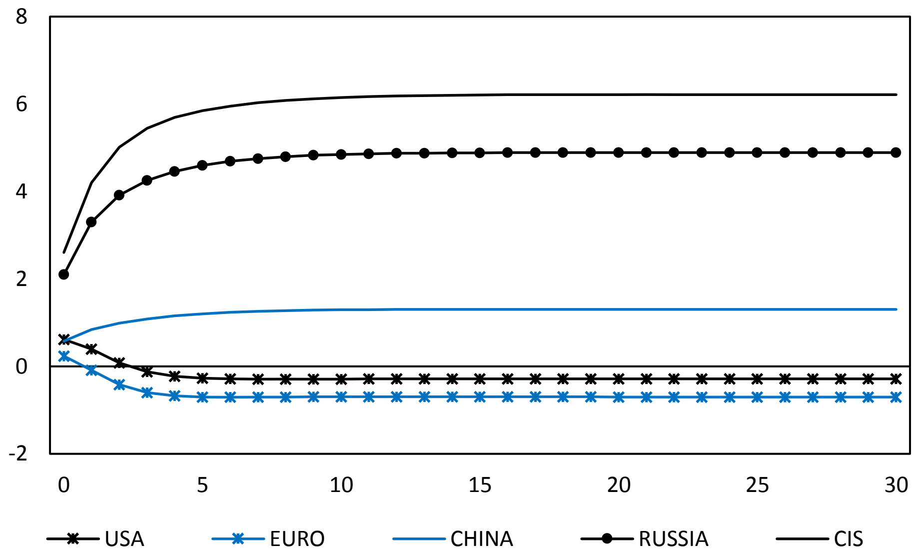


Figure 5. Generalized impulse responses of real activity to 50 % oil price shock.



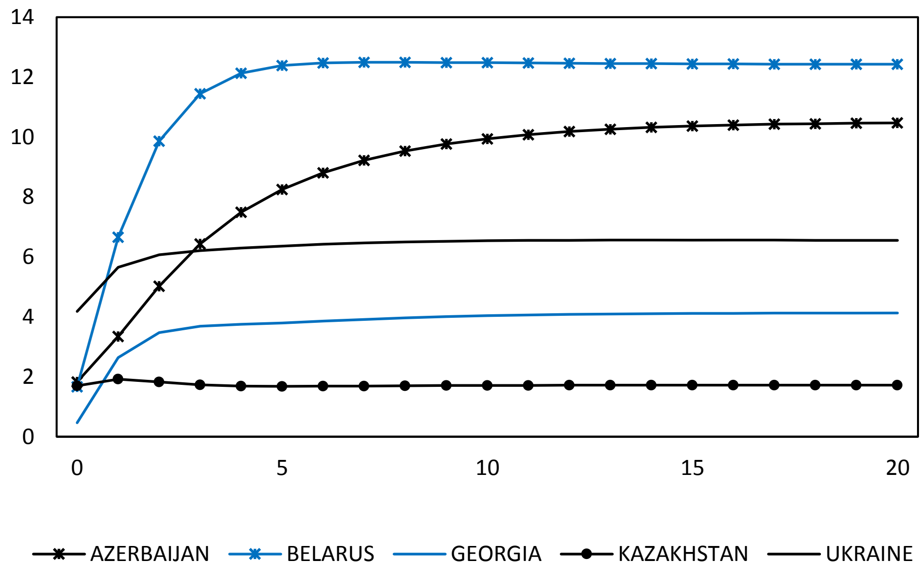
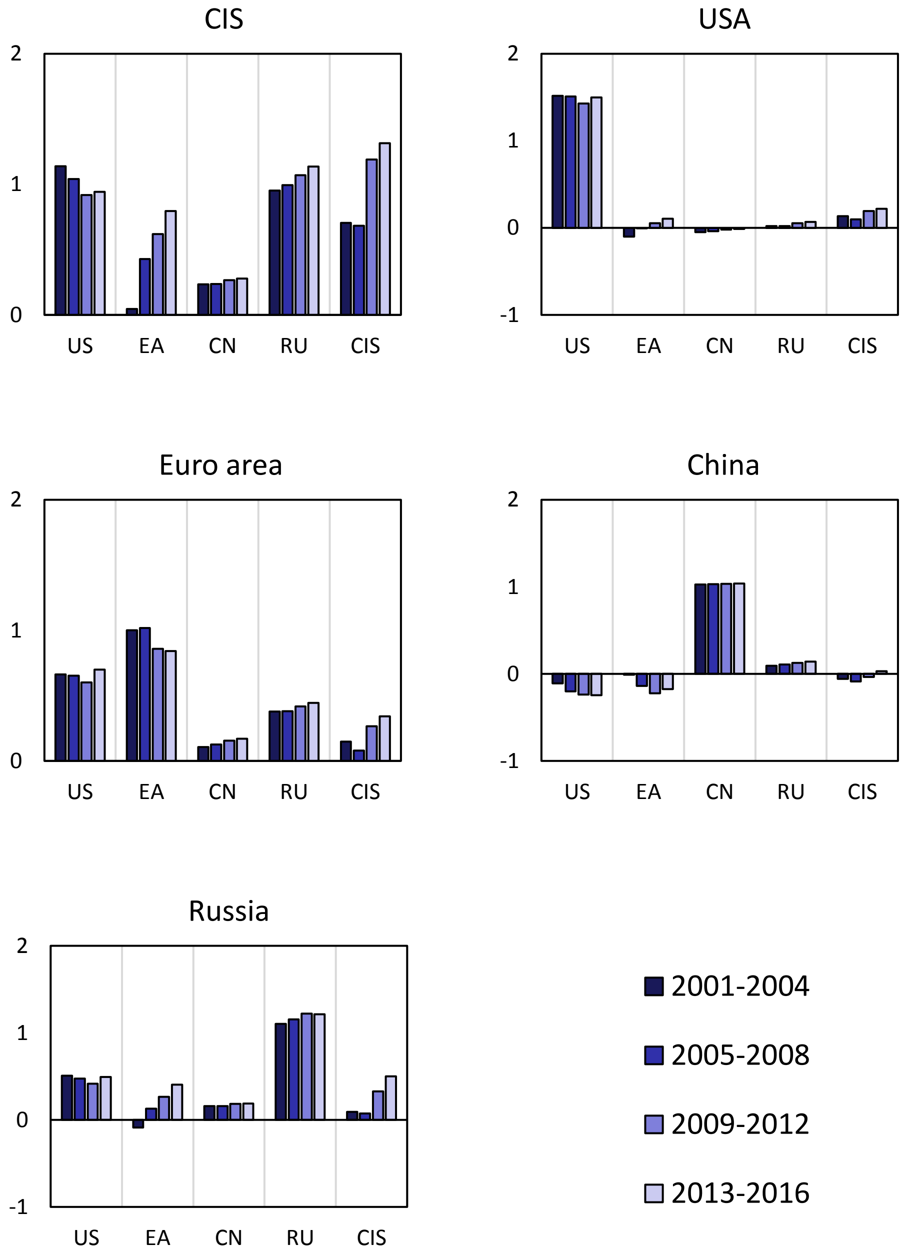
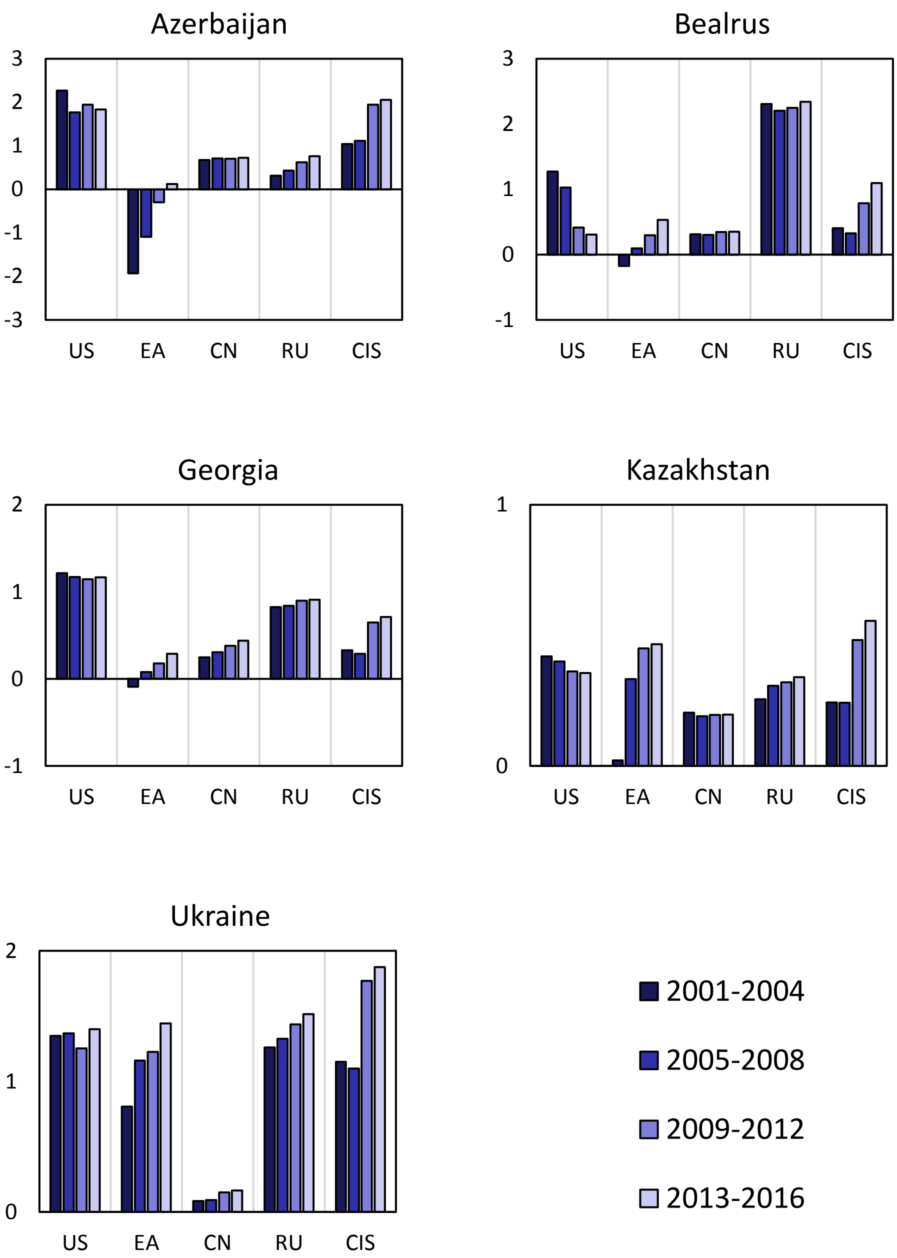


Figure 6. Evolution of long-run responses in major economies to 1 % output shocks in the US, euro area, China, Russia and CIS (affected region in the heading, shock origins depicted by lines).



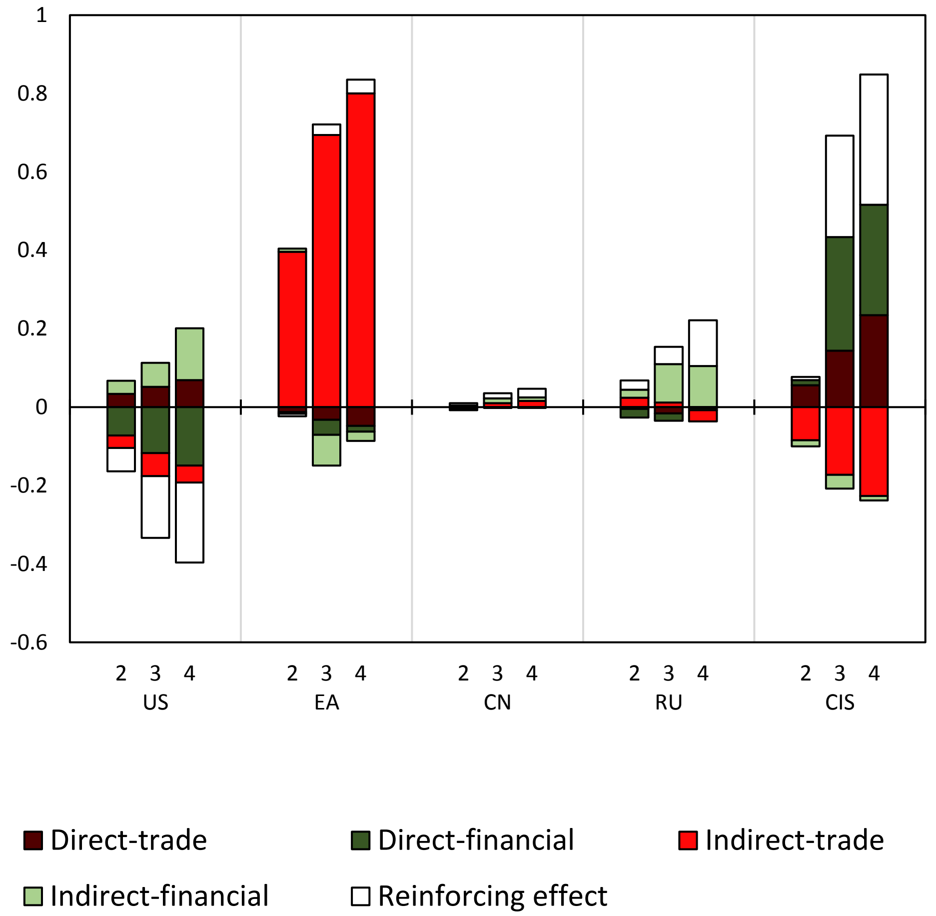
Note: Long-run responses are computed at the 30th period.

Figure 7. Evolution of long-run responses in individual CIS countries to 1 % output shocks in the US, euro area, China, Russia and CIS (affected region in the heading, shock origins depicted by lines).



Note: Long-run responses are computed at the 30th period.

Figure 8. The marginal direct and indirect effect of changing trade and financial linkages on the long-run responses in the aggregated CIS region to 1 % output shocks in the US, euro area, China, Russia and CIS.



Note. The numbers in the horizontal axis refer to time periods (2=2005–08, 3=2009–12, 4=2013–16) and the bars show the difference compared to the baseline of 2001–04. Reinforcing effect refers to the residual.

Figure 9. Marginal direct and indirect effects of changing trade and financial linkages on the long-run responses in individual CIS countries to 1 % output shocks in the US, euro area, China, Russia and CIS.

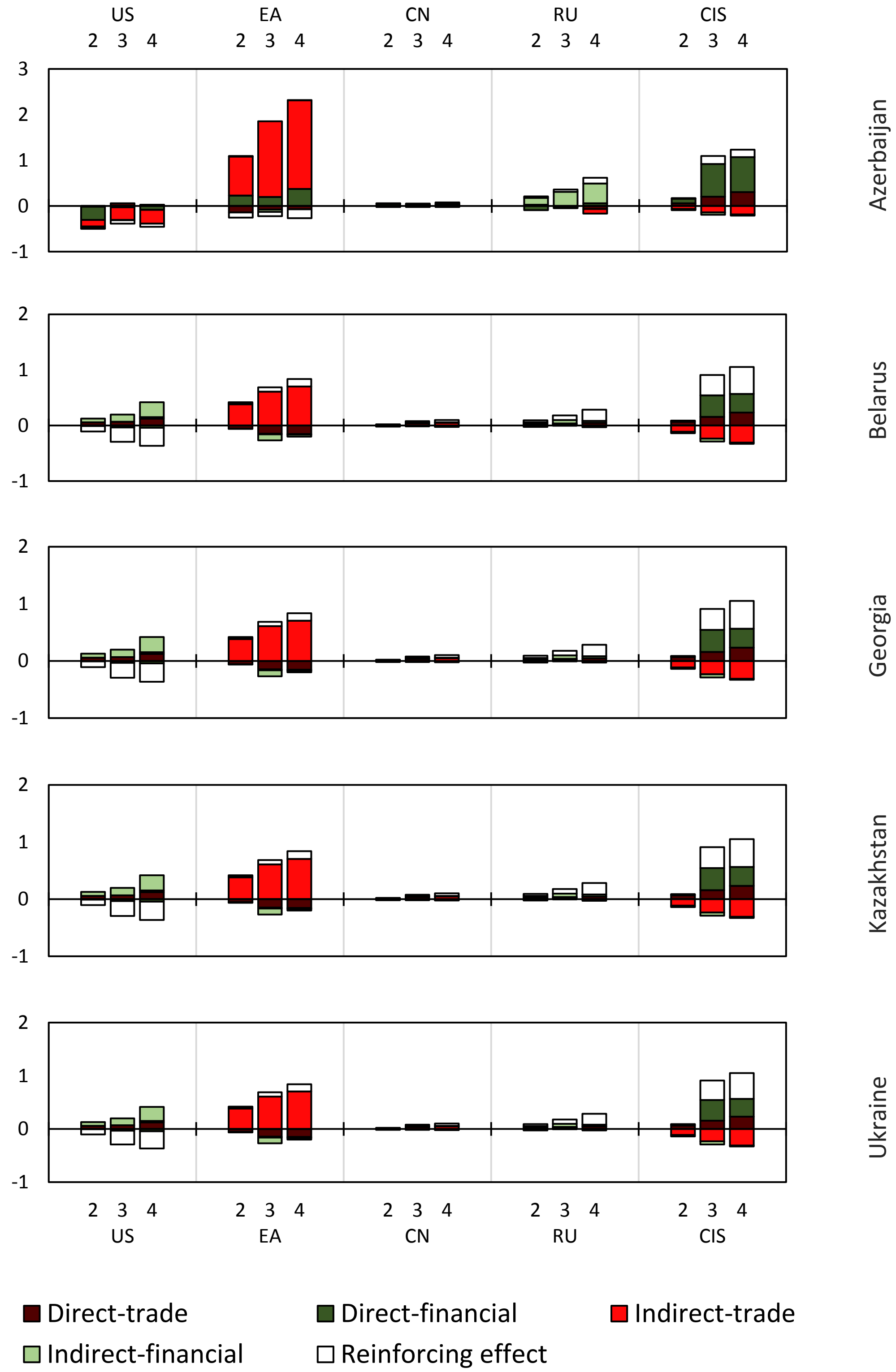
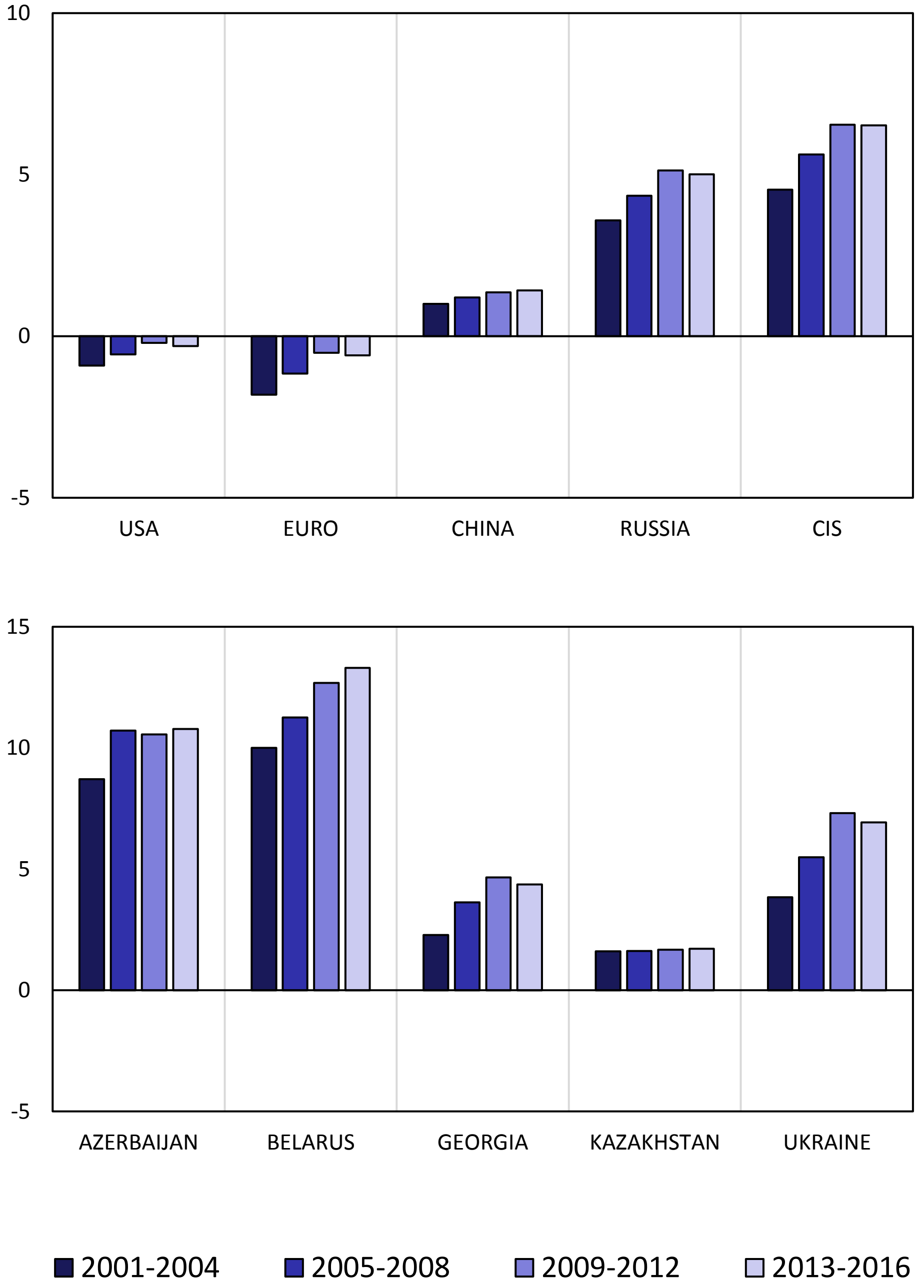


Figure 10. Evolution of long-run responses to 50 % oil price shock.



Note: Long-run responses are computed at the 30th period.