# EXCHANGE MARKET PRESSURE AND REGIONAL PRICE SPILLOVERS IN RUSSIA, UKRAINE, AND BELARUS

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**Abstract**
The economies of Russia, Ukraine, and Belarus have long been undergoing an uneven process of regional integration, but at the same time face the lasting effects of the 2008 Global Financial Crisis. This study examines different measures of Exchange Market Pressure (EMP), which captures currency depreciations and central-bank measures to offset them, for these three countries. We then enter them into vectors that include Russian and foreign stock prices and commodity prices. Impulse response functions and variance decompositions uncover a number of spillovers, particularly when our "benchmark" EMP measure is used. We find evidence of one-way transmission from Russia to Ukraine and Belarus, and from Russian stock prices to the ruble.

JEL Classification: F31, F41
Keywords: Exchange Market Pressure; Russia; Ukraine; Belarus; Contagion; Vector Autoregression

## 1. Introduction

The global financial crisis of 2008, which led to asset- and exchange-market declines worldwide, was preceded by a commodity "boom" that lifted these markets for many exporters. The detrimental events in global markets, combined with the country's invasion of Georgia, led to pressure on the Russian ruble. Given Russia's goals of further economic integration with its neighbors, it can be expected that events in the ruble market might spill over to Ukraine and Belarus. At the same time, global commodity prices (primarily oil), as well as foreign stock prices, might also have an impact on the region. Since stock and exchange markets are intertwined, we expect there to be additional spillovers among them

This study analyzes the interconnections among all these variables. Using monthly time-series data for the past decade, we create indices of Exchange Market Pressure (EMP) for Russia, Ukraine, and Belarus. This index not only captures currency depreciations, but also the two main central-bank actions that can be used to avoid a decline in the currency's value. As such, EMP can rise even if the currency never falls. In a contribution to the literature on EMP measurement, we create four different measures and compare their performance. We then use Vector Autoregressive (VAR) methods to look for spillovers among the countries' EMP series, as well as stock and commodity prices. We find that our alternative EMP measures do not outperform our baseline measure, and that overall, the "benchmark" measure shows a number of comovements among the three countries' EMP series, stock prices, and oil prices.

The motivation behind the concept of EMP spillovers is straightforward. Should one country face the threat of depreciation, investors might withdraw capital from the country. Depending on their appetite for risk and their confidence in the region, they

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might withdraw investment capital from neighboring countries as well, even if no depreciation occurs. This, investment and “psychological” channels might cause co-movements among exchange rates. Should one currency actually lose value, “real” channels such as trade and exports might lead to a chain of events where one country’s depreciation reduces its imports and, by nature, its partner’s exports, causing its neighbor’s currency to depreciate.

At the same time, asset and exchange markets are closely linked, but the direction of causality, as well as the direction, is theoretically ambiguous. According to one school of thought, put forward by Dornbusch and Fischer (1980), a currency appreciation might reduce a country’s real output, which could cause stock prices to decline. Our preferred approach involves psychological factors, whereby if a currency depreciates, investors might sell off all of the country’s assets, including portfolio investments. Likewise, stock declines might cause investors to repatriate their assets and therefore sell the currency. The international spillovers would then occur via the mechanism outlined above.

Russia, Belarus, and Ukraine share many common characteristics, but their economies also differ greatly. All three central banks have managed their currencies in recent years: Russia to a dollar-euro basket as a managed float, Belarus pegged to a Russian ruble/dollar/euro basket, and Ukraine as a dollar peg (and recent managed float). Their exposure to commodities and degree of economic openness vary as well. Russia exports oil, gas, and other natural resources, while the others are dependent on gas imports at subsidized prices. Each is at a different point in the transition process, with Russia relatively politically stable, Belarus delaying market reforms under President Lukashenka, and Ukraine subject to bitter political rivalries and torn between East and West. We expect each country to generate unique results as a result.

We speculate that drops in the price of oil or of Russian stocks would increase pressure on the ruble, as well as possibly have direct effects on the Belarusian ruble and the Ukrainian hryvnia. World stock prices might also affect all three countries directly, depending on their degree of openness. We also suspect that of all country pairings, Russia would cause more spillovers and be less susceptible, but this hypothesis needs to be tested. Finally, the concept of “commodity currencies” (Cashin *et al.*, 2002) suggests that major exporters see their exchange rates fall along with their export commodity’s price. As Hegerty (2012) showed, these price declines do indeed increase Latin American EMP in certain cases. Therefore, each type of spillover needs to be examined empirically.

The literature on these spillovers, particularly since the Asian crisis of 1997, is vast. Much work has been done on “contagious currency crises,” although defining these terms is in itself difficult. Forbes and Rigobon (2002) note that defining “contagion,” rather than simple co-movements, is not always straightforward. In addition, defining what constitutes a “crisis” is subject to debate. While many studies use EMP indices, they often go further and create a binary measure that equals one only if the index exceeds a certain threshold, such as 1.5 standard deviations above the series mean.

Our approach is to use a weighted average of exchange-rate depreciations, reserve losses, and interest-rate hikes in our index. This methodology was first introduced by Girton and Roper (1977), as well as Weymark (1998), who focused on the first two components of the index. Eichengreen *et al.* (1996) introduced the interest-rate component; this, as well as their weighting scheme, have become standard in the literature. Following previous work by Hegerty (2009, 2011, 2012, 2013), we treat EMP as a continuous variable rather than to define "crisis" periods. This is especially appropriate, given Russia's pre-crisis reserve accumulation and ruble appreciation, which leads to negative EMP.

A number of studies, such as Van Poeck *et al.* (2007) and Stavárek (2010) have studied EMP and currency crises in transition economies, but by far most attention is on the countries that were able to join the European Union in 2004 or 2007. Fewer studies have examined Russia, and Belarus is often omitted. Other analyses (such as Gelos and Sahay, 2001; Gibson and Tsakalotos, 2004; and Sojli, 2007) are only somewhat related to the current study, since they do not measure depreciations the same way, and because commodity and stock prices are rarely included alongside EMP in the literature.

This work builds upon that of Hegerty (2011), who examines seven transition economies (including Russia and Ukraine, but not Belarus) over the period from 1999 to 2009, and finds evidence of direct spillovers. Russia, perhaps surprisingly, was less of a likely source of such shocks than smaller (but more crisis-prone) countries, such as Hungary and Latvia. That study, however, fails to include any external measures or any asset prices. Other studies that do so include Hegerty (2012), but transition economies have not been re-assessed in the same manner.

Here, we also find linkages among stock prices and EMP, confirming the results of certain previous studies. These include Phylaktis and Ravazzolo (2005), who find the U.S. stock market to play a dominant role, and Koseoglu and Cevik (2013), who find that stock prices Granger-cause exchange rates (in both mean and variance) for four Central and Eastern European countries.

This study combines all these strands of the literature to examine the various connections among currency markets, stock prices, and commodity prices for three integrated and important countries. Overall, we uncover a number of interlinkages, many originating in Russia or in global asset markets. This paper proceeds as follows: section II outlines the econometric methodology. Section III presents the results. Section IV concludes.

## 2. Methodology

For this analysis, data are taken from the International Financial Statistics of the International Monetary Fund, covering the period from 2000m12 to 2013m7. These data include all EMP components, as well as Russian, German, and U.S. stock-price indices. In addition, we include oil prices (U.K. Brent) and an index of World commodity prices. One variable, the Belarusian nominal effective exchange rate (NEER), was only available from the central bank's web site.

Using these data, our benchmark EMP index is created for Russia, Ukraine, and Belarus[1] according to Equation (1a):

$$EMP_t = \frac{1}{\sigma_{\Delta e}}\left(\ln E_t - \ln E_{t-1}\right) - \frac{1}{\sigma_{\Delta RES}}\frac{\Delta RES_t}{MB_{t-1}} + \frac{1}{\sigma_{\Delta r}}\Delta\left(r_t - r_t^{US}\right) \qquad (1a)\ .$$

Here, $e$ is the bilateral exchange rate in units per U.S. dollar (so that an increase

[1] Other countries, such as Kazakhstan, do not have all the necessary time series available; as a result, our analysis is limited to these three nations.

represents a depreciation); *MB* is the monetary base, deseasonalized using the Census X-12 procedure; *RES* is total reserves excluding gold, converted to domestic currency; and the *r* series are the Money Market Rate (except for Belarus, for which the Lending Rate is used).

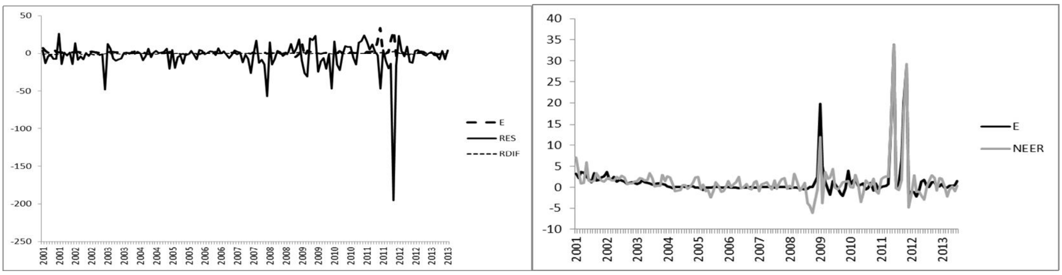
As an alternative to the U.S. dollar as a base currency—which is appropriate for countries that peg to a basket of currencies—we modify the preceding equation to include the nominal effective exchange rate. Since a decrease, rather than an increase, in this variable represents a depreciation, we "switch" the sign of the first component.

$$EMP_t = -\frac{1}{\sigma_{\Delta n}}\left(\ln NEER_t - \ln NEER_{t-1}\right) - \frac{1}{\sigma_{\Delta RES}}\frac{\Delta RES_t}{MB_{t-1}} + \frac{1}{\sigma_{\Delta r}}\Delta\left(r_t - r_t^{US}\right) \quad (1b)\ .$$

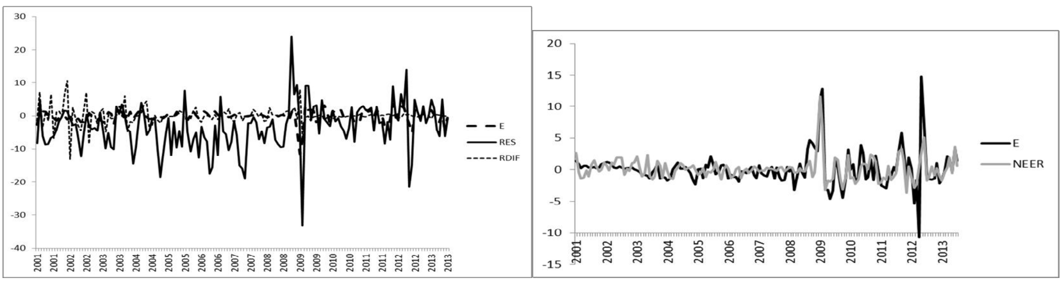
We will then be able to test for differences between these measures. Figure 1 plots the three main components of Equation (1); we see that reserve changes dominate each series, confirming that each exchange rate is heavily managed. Plotting the bilateral rate and effective rates simultaneously also demonstrates that while they are highly correlated, movements in each series are not equally strong.

**Figure 1. EMP Components and Log Changes in Exchange-Rate Series, 2001-2013.**

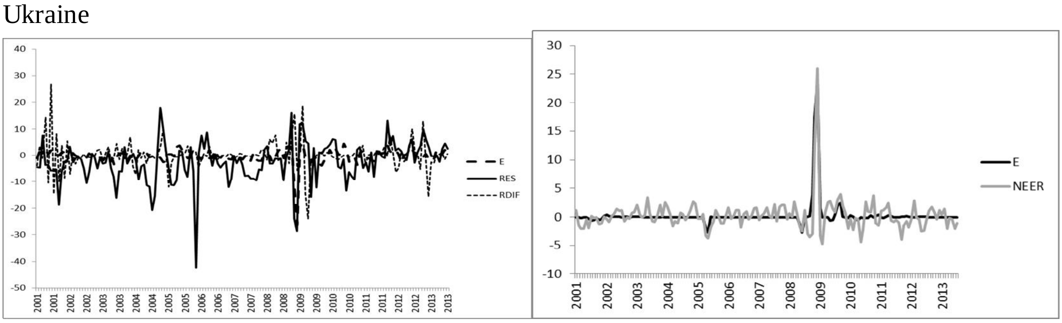
Belarus




Russia




Ukraine




Note: Belarusian data are unmodified, while the signs of the Russian and Ukrainian NEER series are switched so that an increase represents a currency depreciation.

Following Eichengreen, Rose, and Wyplosz (1996), after whom this measure is dubbed the "ERW" measure, each component of the series is deflated by its own standard deviation. This weighting scheme has come under criticism in the literature, partly because it is time-invariant, and alternatives have been proposed. While studies such as Pentecost *et al*. (2001), Pontines and Siregar (2008), and Bertoli *et al.* (2010) have applied alternative measures, none has consistently outperformed the ERW measure. Hegerty (2013) uses Principal Component Analysis (PCA) to assign weights, but finds that, for many of the 21 countries studied, the first principal component does not produce factor loadings with appropriate signs. For some (including Russia and Ukraine), the second or third principal component can be used, but this measure often has smaller movements than the ERW measure and is less likely to point to currency "crises."

In this study, we generate the appropriate principal component for exchange-rate depreciations, reserve changes (which must carry a negative sign) and changes to the interest-rate differential, using both the bilateral and effective exchange rates, and use it as an alternative EMP measure. We then use our three (for Belarus) and four (for Ukraine and Russia) EMP measures in the next phase of our analysis.

We continue by entering each group of EMP measures into a single VAR that includes an index of Russian stock prices, oil prices, and "world" stock prices. All price series are entered in log changes. This latter measure is constructed as the first principal component of U.S. and German stock indices. We therefore estimate four VARs, one each for the ERW measure and PCA measure, using bilateral and effective exchange rates. A fifth vector uses our "benchmark" ERW, bilateral EMP measure, but with the IMF's index of world commodity prices in place of the oil price. Our basic VAR is therefore

$$\left[EMP^{BY}, EMP^{RU}, EMP^{UA}, \Delta\ln P^{S}_{RU}, \Delta\ln P^{Oil}, \Delta\ln P^{S}_{World}\right] \qquad (2),$$

and is estimated at a lag length that minimizes the Schwarz Information Criterion (SIC).

For each VAR, we follow a standard three-part approach, which is similar to that of Hegerty (2011). First, we conduct Granger Causality (Block exogeneity) tests to see whether the addition of a variable increases explanatory power in a regression involving another variable. Second—which is our primary approach—we generate impulse-response functions (IRFs), whereby we investigate the impact of shocks to each variable on our EMP indices and Russian stock prices. Because the orthogonalized VAR approach of Sims (1980) requires a logical ordering of the variables for a Cholesky decomposition, and because there is no such ordering for our variables, we apply the Generalized VAR approach of Pesaran and Shin (1998). Thirdly, we calculate generalized forecast error variance decompositions (FEVDs) for each variable. These turn out to support the conclusions of the IRFs almost exactly.

These tests will allow us to see which exchange markets serve as "sources" of shocks, whereby an increase in EMP might lead to a crisis in a neighbor. It will also allow us to see which countries are most vulnerable to spillovers. Thirdly, we investigate spillovers among asset markets and exchange markets. We expect there to be a relationship among the Russian stock market, the ruble, and the world oil price, although we need to uncover whether or not each relationship is unidirectional or bidirectional. In addition, our study will show whether Belarus and Ukraine are subject to similar interactions. Our results are provided below.

## 3. Results

We begin by looking at the three components of our EMP index, which are shown in Figure 1. As is expected for countries that follow managed exchange-rate regimes with a dollar peg, reserve changes are larger than movements in the nominal bilateral dollar rate or in the interest-rate differential. Because we include each country's effective rate in an alternative calculation of EMP, we also plot both exchange rates together on the right side of Figure 1. Clearly both series move together. But the magnitude of each change differs, however, which has implications for our results.

We use each set of components to generate EMP series using PCA rather than variance-based weights. These results are shown in Table 1. Using the bilateral dollar rate, only Russia and Ukraine have a principal component that has both an eigenvalue above one and the appropriate signs (positive for the exchange-rate and interest-rate components, negative for reserve changes). These are the second, rather than the first, components. Using the effective rate, Russia's second and Ukraine's third principal components appear to be suitable, but only by relaxing the eigenvalue criterion can we include Belarus' third principal component in our analysis.

We therefore have four alternative EMP measures for Russia and Ukraine, and three for Belarus. Table 2 presents the correlations among each vector. We also include a fifth—an "incorrect" first principal component—to show how the wrong signs can lead to an inappropriate EMP measure. We see in Table 2 that the appropriate series are all highly correlated with one another.

**Table 1. Principal Components Analysis of EMP Series.**

Nominal, Bilateral

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Eigenvalues | | | | | | | | | |
| | *Belarus* | | | *Russia* | | | *Ukraine* | | |
| Number | Value | Prop. | | Value | Prop. | | Value | Prop. | |
| 1 | 1.800 | 0.600 | | 1.370 | 0.457 | | 1.310 | 0.437 | |
| 2 | 0.770 | 0.257 | | 1.074 | 0.358 | | 1.027 | 0.342 | |
| 3 | 0.430 | 0.144 | | 0.557 | 0.186 | | 0.663 | 0.221 | |
| Eigenvectors (loadings): | | | | | | | | | |
| Variable | PC 1 | PC 2 | PC 3 | PC 1 | **PC 2** | PC 3 | PC 1 | **PC 2** | PC 3 |
| E | 0.636 | -0.217 | -0.741 | 0.582 | **0.569** | -0.580 | 0.715 | **0.129** | -0.687 |
| RES | 0.603 | -0.460 | 0.652 | 0.736 | **-0.067** | 0.673 | 0.691 | **-0.278** | 0.667 |
| RDIFF | 0.482 | 0.861 | 0.162 | -0.344 | **0.819** | 0.459 | 0.105 | **0.952** | 0.288 |

Nominal Effective

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Eigenvalues | | | | | | | | | |
| | *Belarus* | | | *Russia* | | | *Ukraine* | | |
| Number | Value | Prop. | | Value | Prop. | | Value | Prop. | |
| 1 | 1.719 | 0.573 | | 1.389 | 0.463 | | 1.409 | 0.470 | |
| 2 | 0.809 | 0.270 | | 1.062 | 0.354 | | 0.974 | 0.325 | |
| 3 | 0.473 | 0.158 | | 0.549 | 0.183 | | 0.616 | 0.206 | |
| Eigenvectors (loadings): | | | | | | | | | |
| Variable | PC 1 | PC 2 | **PC 3** | PC 1 | **PC 2** | PC 3 | PC 1 | PC 2 | **PC 3** |
| E | 0.628 | -0.327 | **0.706** | 0.592 | **0.553** | -0.587 | 0.692 | 0.107 | **0.714** |
| RES | 0.629 | -0.321 | **-0.708** | 0.731 | **-0.062** | 0.679 | 0.672 | 0.265 | **-0.691** |
| RDIFF | 0.459 | 0.889 | **0.004** | -0.339 | **0.831** | 0.441 | -0.264 | 0.958 | **0.111** |

Bold = Principal component meets sign restrictions.

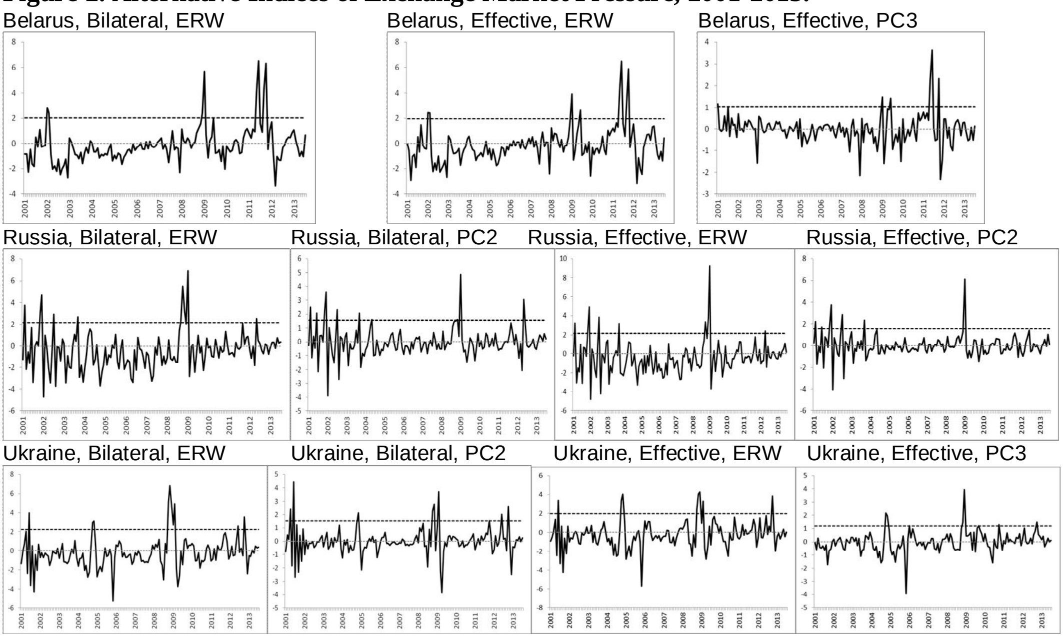
**Table 2. Correlations Among Alternative EMP Series.**

| | BYEMP | BYNEMP | BYNPC1 | BYNPC2 | BYNPC3 |
|---|---|---|---|---|---|
| BYEMP | 1 | 0.948 | 0.416 | 0.636 | 0.580 |
| BYNEMP | | 1 | 0.431 | 0.569 | 0.700 |
| BYNPC1 | | | 1 | 0.000 | 0.000 |
| BYNPC2 | | | | 1 | 0.000 |
| BYNPC3 | | | | | 1 |
| | RUEMP | RUNEMP | RUNPC2 | RUPC1 | RUPC2 |
| RUEMP | 1 | 0.886 | 0.766 | -0.338 | 0.876 |
| RUNEMP | | 1 | 0.873 | -0.432 | 0.770 |
| RUNPC2 | | | 1 | -0.093 | 0.901 |
| RUPC1 | | | | 1 | 0.000 |
| RUPC2 | | | | | 1 |
| | UAEMP | UANEMP | UANPC3 | UAPC1 | UAPC2 |
| UAEMP | 1 | 0.924 | 0.675 | 0.090 | 0.843 |
| UANEMP | | 1 | 0.817 | 0.034 | 0.784 |
| UANPC3 | | | 1 | -0.024 | 0.291 |
| UAPC1 | | | | 1 | 0.000 |
| UAPC2 | | | | | 1 |

Note: EMP = ERW, bilateral; NEMP = ERW, effective; NPC = Principal component, using NEER; PC = Principal component, using bilateral rate.

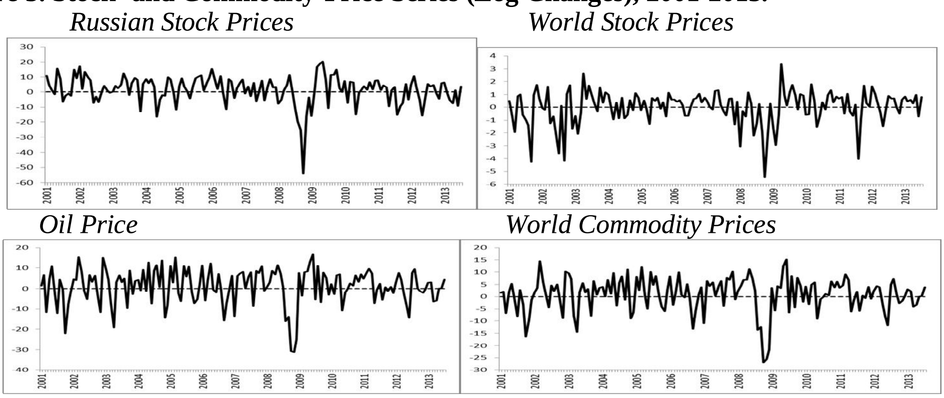
Figure 2 plots these series side by side. They tend to show similar movements and "spikes," although again the magnitude differs. The early 2000s, the 2008 crisis, and 2011-2012 can be defined as "crises," where EMP exceeds 1.5 standard deviations above each series mean. We also see stock- and oil-price declines during these periods in Figure 3. In particular, the world stock-index proxy drops sharply in 2011. We expect to find spillovers among our time series as a result.

**Figure 2. Alternative Indices of Exchange Market Pressure, 2001-2013.**



Our first step in isolating these spillovers is with our Granger causality tests, the results of which are presented in Table 3. Each VAR in this study is estimated at one lag, which minimizes the SIC. Oil-price changes Granger-cause EMP in all specifications, but otherwise there is little in the way of significant coefficients. The only exception is that Belarusian EMP Granger-causes EMP in Ukraine. The Generalized IRFs are far more informative. They are given in Figure 3. We first find that the NEER-based ERW measure produces fewer significant impulse responses than does the "benchmark" bilateral ERW measure. In addition, the PCA measures have fewer responses than the ERW measure. This implies that the bilateral ERW measure is more likely to show evidence of "crisis" transmission than others. As Hegerty (2013) showed, this was true for the ERW relative to the PCA measure; here, it is also true for the bilateral versus the NEER measure. As such, the "benchmark" model generates a large number of spillovers, and remains the one on which we focus the most. Belarus and Ukraine respond to all other series, with the expected sign. Increases in each country's EMP, as well as Russia's, lead to increases in the other's EMP. Declines in the world oil price and Russian and World stock markets also put pressure on the two currencies. While Russia is an important source of shocks to Belarusian and Ukrainian EMP, the country appears not to be vulnerable to spillovers from its smaller neighbors. Russian stocks, and to a lesser extent oil prices and foreign stock prices, do have an impact on the ruble. Finally, increases in oil prices and foreign stock indices help decrease Russian EMP, but there is no spillover from currency markets to stock markets in the region.

**Figure 3. Stock- and Commodity-Price Series (Log Changes), 2001-2013.**




We provide IRFs for VARs that include each of the other three EMP measures. It is important to note, since there is no usable PCA measure of the bilateral EMP series for Belarus, we simply use Belarus ERW measure in place of the PCA measure in that particular vector. Overall, there are fewer significant results than were uncovered via the benchmark model. This is especially true for Ukraine and Belarus for the two NEER-based measures, but nevertheless, the Russian ruble is still susceptible to spillovers from oil prices and stock markets. These "foreign" variables generate significant responses for Belarus and Ukraine when the bilateral PCA approach is used; the spillover from Belarus to Ukraine is shown in this specification as well. This is also true for the VAR that includes the set of bilateral PCA measures. The VAR that includes the bilateral ERW EMP series from the first specification, but with world commodity prices replacing the oil price shows all the same responses, and EMP in all countries increases if commodity prices decline.

| Table 3. Granger causality test results | | | | |
|---|---|---|---|---|
| ERW, NEER | | | | |
| | BYNEMP | RUNEMP | UANEMP | DLRUPS |
| Excluded | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) |
| BYNEMP | 0.029 (0.864) | 0.075 (0.785) | 2.261 (0.133) | 0.172 (0.678) |
| RUNEMP | | 0.069 (0.792) | 0.674 (0.412) | 0.258 (0.612) |
| UANEMP | 2.259 (0.133) | | 0.804 (0.370) | 0.309 (0.578) |
| DLRUPS | 0.659 (0.417) | 0.106 (0.745) | | 0.000 (0.989) |
| DLPOIL | 2.269 (0.132) | **16.328 (0.000)** | 0.076 (0.783) | |
| DLPSPC | 0.497 (0.481) | 0.041 (0.840) | 0.051 (0.821) | 2.668 (0.102) |
| All | 5.889 (0.317) | **21.905 (0.001)** | 6.092 (0.297) | 3.386 (0.641) |
| PCA, NEER | | | | |
| | BYNPC3 | RUNPC2 | UANPC3 | DLRUPS |
| Excluded | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) |
| BYNPC3 | | 0.392 (0.531) | 0.446 (0.504) | 0.272 (0.602) |
| RUNPC1 | 0.039 (0.843) | | 0.105 (0.746) | 1.077 (0.300) |
| UANPC1 | 0.465 (0.495) | 1.414 (0.234) | | 1.229 (0.268) |
| DLRUPS | 2.029 (0.154) | 0.079 (0.779) | 0.478 (0.489) | |
| DLPOIL | 0.352 (0.553) | **10.071 (0.002)** | 0.490 (0.484) | 0.014 (0.907) |
| DLPSPC | 0.093 (0.761) | 0.037 (0.848) | 0.158 (0.691) | **2.838 (0.092)** |
| All | 3.081 (0.688) | **19.239 (0.002)** | 3.438 (0.633) | 5.445 (0.364) |
| | Bold = significant at 10 percent. | | | |

| ERW, Bilateral | | | | |
|---|---|---|---|---|
| | BYEMP | RUEMP | UAEMP | DLRUPS |
| Excluded | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) |
| BYEMP | | 1.098 (0.295) | **3.676 (0.055)** | 0.084 (0.773) |
| RUEMP | 0.824 (0.364) | | 0.856 (0.355) | 1.594 (0.207) |
| UAEMP | 1.275 (0.259) | 0.751 (0.386) | | 0.000 (0.989) |
| DLRUPS | 0.409 (0.523) | 0.181 (0.670) | 2.347 (0.126) | |
| DLPOIL | 2.190 (0.139) | **13.174 (0.000)** | 0.034 (0.853) | 0.016 (0.899) |
| DLPSPC | 0.786 (0.375) | 0.408 (0.523) | 0.081 (0.776) | **2.809 (0.094)** |
| All | 8.211 (0.145) | **22.691 (0.000)** | 14.392 (0.013) | 4.308 (0.506) |
| PCA, Bilateral | | | | |
| | BYEMP | RUPC2 | UAPC2 | DLRUPS |
| Excluded | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) |
| BYEMP | | 1.058 (0.304) | **3.523 (0.061)** | 0.074 (0.785) |
| RUPC2 | 0.001 (0.976) | | 0.175 (0.676) | **3.214 (0.073)** |
| UAPC2 | 0.055 (0.815) | **5.083 (0.024)** | | 0.030 (0.863) |
| DLRUPS | 0.106 (0.744) | 1.509 (0.219) | **3.013 (0.083)** | |
| DLPOIL | **3.521 (0.061)** | **11.025 (0.001)** | 0.188 (0.665) | 0.018 (0.893) |
| PCSTOCK | 1.100 (0.294) | 0.627 (0.429) | 0.047 (0.828) | **3.113 (0.078)** |
| All | 5.859 (0.320) | **30.149 (0.000)** | **11.915 (0.036)** | 6.221 (0.285) |

| World P(C) | | | | |
|---|---|---|---|---|
| | BYEMP | RUEMP | UAEMP | DLRUPS |
| Excluded | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) | Chi-sq (Prob.) |
| BYEMP | | 1.090 (0.296) | **3.784 (0.052)** | 0.070 (0.791) |
| RUEMP | 0.641 (0.423) | | 0.738 (0.390) | 1.485 (0.223) |
| UAEMP | 1.314 (0.252) | 0.772 (0.380) | | 0.011 (0.917) |
| DLRUPS | 0.381 (0.537) | 0.171 (0.679) | 1.823 (0.177) | |
| DLWPC | 2.195 (0.139) | **14.707 (0.000)** | 0.371 (0.543) | 0.070 (0.792) |
| DLPSPC | 0.762 (0.383) | 0.409 (0.522) | 0.133 (0.715) | 2.572 (0.109) |
| All | 8.216 (0.145) | **24.317 (0.000)** | **14.762 (0.011)** | 4.364 (0.498) |

**Table 4. Forecast Error Variance Deecompositions At One, Four, and Twelve Months.**

| Russia | | | | | | |
|---|---|---|---|---|---|---|
| Horizon | BYEMP | RUEMP | UAEMP | **DLRUPS** | **DLPOIL** | **DLWPS** |
| 1 | 0.023 | 0.885 | 0.026 | **0.167** | **0.139** | **0.049** |
| 4 | 0.024 | 0.859 | 0.029 | **0.185** | **0.143** | **0.071** |
| 12 | 0.024 | 0.859 | 0.029 | **0.185** | **0.143** | **0.071** |
| Russian P(S) | | | | | | |
| Horizon | BYEMP | **RUEMP** | UAEMP | DLRUPS | **DLPOIL** | **DLWPS** |
| 1 | 0.020 | **0.112** | 0.047 | 0.977 | **0.213** | **0.258** |
| 4 | 0.019 | **0.108** | 0.048 | 0.969 | **0.206** | **0.270** |
| 12 | 0.019 | **0.108** | 0.048 | 0.969 | **0.206** | **0.270** |
| Russia | | | | | | |
| Horizon | BYEMP | RUPC2 | UAP2 | **DLRUPS** | **DLPOIL** | DLWPS |
| 1 | 0.013 | 0.886 | 0.002 | **0.093** | **0.120** | 0.024 |
| 4 | 0.013 | 0.866 | 0.003 | **0.106** | **0.124** | 0.040 |
| 12 | 0.013 | 0.865 | 0.003 | **0.106** | **0.124** | 0.040 |
| Russian P(S) | | | | | | |
| Horizon | BYEMP | **RUPC2** | UAP2 | DLRUPS | **DLPOIL** | **DLWPS** |
| 1 | 0.001 | **0.075** | 0.003 | 0.981 | **0.201** | **0.265** |
| 4 | 0.001 | **0.075** | 0.005 | 0.975 | **0.196** | **0.276** |
| 12 | 0.001 | **0.075** | 0.005 | 0.975 | **0.196** | **0.276** |
| Russia | | | | | | |
| Horizon | BYEMP | RUPC2 | **UAPC2** | **DLRUPS** | **DLPOIL** | **DLWPS** |
| 1 | 0.012 | 0.856 | **0.065** | **0.124** | **0.104** | **0.050** |
| 4 | 0.012 | 0.834 | **0.074** | **0.135** | **0.103** | **0.068** |
| 12 | 0.012 | 0.834 | **0.074** | **0.136** | **0.103** | **0.068** |
| Russian P(S) | | | | | | |
| Horizon | BYEMP | **RUPC2** | UAPC2 | DLRUPS | **DLPOIL** | **DLWPS** |
| 1 | 0.018 | **0.077** | 0.047 | 0.969 | **0.213** | **0.254** |
| 4 | 0.017 | **0.074** | 0.049 | 0.960 | **0.205** | **0.266** |
| 12 | 0.017 | **0.074** | 0.049 | 0.960 | **0.205** | **0.266** |
| Russia | | | | | | |
| Horizon | BYNPC3 | RUNPC2 | UANPC3 | **DLRUPS** | **DLPOIL** | DLWPS |
| 1 | 0.003 | 0.905 | 0.031 | **0.064** | **0.084** | 0.027 |
| 4 | 0.003 | 0.889 | 0.032 | **0.073** | **0.084** | 0.039 |
| 12 | 0.003 | 0.889 | 0.032 | **0.073** | **0.084** | 0.039 |
| Russian P(S) | | | | | | |
| Horizon | BYNPC3 | RUNPC2 | UANPC3 | DLRUPS | **DLPOIL** | **DLWPS** |
| 1 | 0.012 | 0.047 | 0.020 | 0.970 | **0.199** | **0.259** |
| 4 | 0.012 | 0.045 | 0.021 | 0.961 | **0.193** | **0.270** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | 0.012 | 0.045 | 0.021 | 0.961 | **0.193** | **0.270** |
| Russia | | | | | | |
| Horizon | BYEMP | RUEMP | UAEMP | **DLRUPS** | **DLWPC** | **DLWPS** |
| 1 | 0.022 | 0.880 | 0.022 | **0.173** | **0.156** | **0.049** |
| 4 | 0.023 | 0.850 | 0.026 | **0.193** | **0.163** | **0.072** |
| 12 | 0.023 | 0.850 | 0.026 | **0.194** | **0.163** | **0.073** |
| Russian P(S) | | | | | | |
| Horizon | BYEMP | **RUEMP** | UAEMP | DLRUPS | **DLWPC** | **DLWPS** |
| 1 | 0.021 | **0.121** | 0.048 | 0.977 | **0.212** | **0.257** |
| 4 | 0.021 | **0.116** | 0.049 | 0.968 | **0.204** | **0.266** |
| 12 | 0.021 | **0.116** | 0.049 | 0.968 | **0.204** | **0.266** |

Bold = Greater than 0.5 (not including “own variance” cases).

| | | | | | | |
|---|---|---|---|---|---|---|
| ERW, Bilateral | Belarus | | | | | |
| Horizon | BYEMP | **RUEMP** | UAEMP | **DLRUPS** | DLPOIL | DLWPS |
| 1 | 0.966 | **0.041** | 0.017 | **0.033** | 0.015 | 0.012 |
| 4 | 0.920 | **0.061** | 0.034 | **0.063** | 0.035 | 0.032 |
| 12 | 0.916 | **0.061** | 0.035 | **0.067** | 0.036 | 0.034 |
| | Ukraine | | | | | |
| Horizon | BYEMP | **RUEMP** | UAEMP | **DLRUPS** | **DLPOIL** | **DLWPS** |
| 1 | 0.027 | **0.061** | 0.934 | **0.112** | **0.078** | **0.037** |
| 4 | 0.045 | **0.069** | 0.884 | **0.150** | **0.089** | **0.057** |
| 12 | 0.046 | **0.069** | 0.882 | **0.151** | **0.089** | **0.058** |
| ERW, NEER | Belarus | | | | | |
| Horizon | BYEMP | RUPC2 | UAP2 | DLRUPS | DLPOIL | DLWPS |
| 1 | 0.972 | 0.016 | 0.013 | 0.001 | 0.016 | 0.001 |
| 4 | 0.948 | 0.020 | 0.023 | 0.004 | 0.020 | 0.005 |
| 12 | 0.947 | 0.021 | 0.023 | 0.005 | 0.021 | 0.006 |
| | Ukraine | | | | | |
| Horizon | BYEMP | RUPC2 | UAP2 | DLRUPS | DLPOIL | DLWPS |
| 1 | 0.011 | 0.014 | 0.971 | 0.014 | 0.023 | 0.001 |
| 4 | 0.018 | 0.017 | 0.951 | 0.023 | 0.029 | 0.006 |
| 12 | 0.019 | 0.017 | 0.950 | 0.024 | 0.029 | 0.006 |
| PCA, Bilateral | Belarus | | | | | |
| Horizon | BYEMP | RUPC2 | UAPC2 | **DLRUPS** | DLPOIL | DLWPS |
| 1 | 0.975 | 0.009 | 0.002 | **0.032** | 0.019 | 0.013 |
| 4 | 0.946 | 0.013 | 0.004 | **0.054** | 0.032 | 0.032 |
| 12 | 0.944 | 0.013 | 0.004 | **0.056** | 0.032 | 0.034 |
| | Ukraine | | | | | |
| Horizon | BYEMP | **RUPC2** | UAPC2 | **DLRUPS** | DLPOIL | DLWPS |
| 1 | 0.030 | **0.058** | 0.943 | **0.074** | 0.037 | 0.033 |
| 4 | 0.033 | **0.058** | 0.931 | **0.081** | 0.039 | 0.036 |
| 12 | 0.033 | **0.058** | 0.931 | **0.081** | 0.039 | 0.036 |
| PCA, NEER | Belarus | | | | | |
| Horizon | BYNPC3 | RUNPC2 | UANPC3 | DLRUPS | DLPOIL | DLWPS |
| 1 | 0.981 | 0.004 | 0.011 | 0.030 | 0.019 | 0.008 |
| 4 | 0.978 | 0.004 | 0.012 | 0.032 | 0.019 | 0.009 |
| 12 | 0.978 | 0.004 | 0.012 | 0.032 | 0.019 | 0.009 |
| | Ukraine | | | | | |
| Horizon | BYNPC3 | RUNPC2 | UANPC3 | DLRUPS | DLPOIL | DLWPS |
| 1 | 0.006 | 0.017 | 0.984 | 0.022 | 0.017 | 0.006 |
| 4 | 0.006 | 0.016 | 0.970 | 0.028 | 0.024 | 0.008 |
| 12 | 0.006 | 0.016 | 0.970 | 0.028 | 0.024 | 0.008 |

| ERW, World P | Belarus | | | | | |
|---|---|---|---|---|---|---|
| Horizon | BYEMP | **RUEMP** | UAEMP | **DLRUPS** | DLWPC | DLWPS |
| 1 | 0.968 | **0.039** | 0.015 | **0.035** | 0.015 | 0.012 |
| 4 | 0.917 | **0.058** | 0.033 | **0.067** | 0.039 | 0.032 |
| 12 | 0.912 | **0.059** | 0.034 | **0.071** | 0.040 | 0.035 |
| | Ukraine | | | | | |
| Horizon | BYEMP | **RUEMP** | UAEMP | **DLRUPS** | **DLWPC** | **DLWPS** |
| 1 | 0.026 | **0.057** | 0.933 | **0.113** | **0.079** | **0.038** |
| 4 | 0.044 | **0.066** | 0.880 | **0.152** | **0.093** | **0.059** |
| 12 | 0.044 | **0.066** | 0.878 | **0.154** | **0.093** | **0.060** |

Finally, forecast error variance decompositions for one, four, and 12 months ahead are provided in Table 4. While Generalized FEVDs do not necessarily sum to one, and therefore are not percentages, we have bolded relatively large values based on a threshold of 0.05. The FEVDs correspond closely to the IRF results, particularly if one considers values above 0.03. Russian stock prices are highly influential on the exchange markets of Russia and Ukraine, while oil prices affect the Russian ruble most and the hryvnia least. The ruble has some impact on Russia's stock market, but world markets have a larger one. Belarus and Ukraine also experience spillovers from Russia. These results therefore support our overall conclusion of one-way transmission in the region.

## 4. Conclusion

Since well before the 2008 financial crisis, Russia and its neighbors have been susceptible to shocks to world commodity prices, foreign stock markets, and global demand. These forces have been exacerbated by the often uneven process of regional (re-) integration among Russia, Ukraine, and Belarus. This study examines exchange-market linkages among this group, as well as these currencies' vulnerability to external shocks. In particular, we calculate indices of exchange market pressure (EMP) for each country, before using VAR methods to test for spillovers.

While we estimate various alternative EMP measures—using effective as well as nominal exchange rates, and principal components as well as variance-deflating weights—we do not find any evidence that these measures are superior over our benchmark model. We do conclude, that measures incorporating effective exchange rates are less likely to register spillovers. Our "benchmark" measure (using nominal rates and variance-smoothing weights) leads us to a number of important conclusions regarding the region.

Estimating vectors that include the three countries EMP series, oil prices, and stock prices for Russia and the West, we conduct Granger causality tests, generate impulse-response functions, and calculate forecast error variance decompositions. We find, particularly via the latter two techniques, that Ukrainian and Belarusian EMP spill over between each other, and that both experience spillovers that originate in Russia. Russia, on the other hand, is less affected by events in its neighbors' exchange markets. But, like the others, is vulnerable to declines in the oil price and stock markets. The transmission from Russian stock prices to EMP is unidirectional, however; the ruble does not influence Russian stocks.

This has important implications for regional integration. Clearly, Russia is the dominant economy in the region, so it is no surprise that the ruble exerts a strong influence.

But this study provides further proof that Russia's central bank can have an outsize influence beyond its borders. It also shows that further currency integration may provide a disproportionate benefit to Russia.

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Annex on line at the journal Website: http://www.usc.es/economet/aeid.htm

Annex

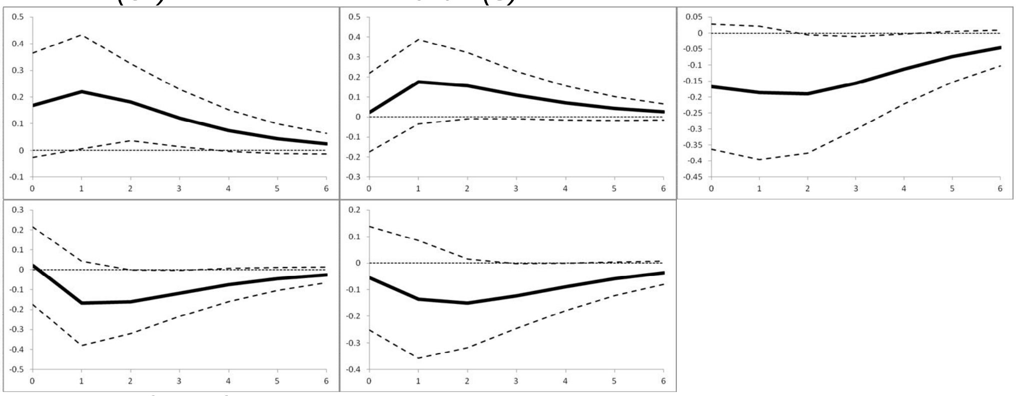
**Figure 4. Generalized Impulse Response Functions, With ±2 Standard Error Bands.**

*ERW Measure, Bilateral*

*Response of Belarus:*

*Russia* *Ukraine* *Russia P(S)*

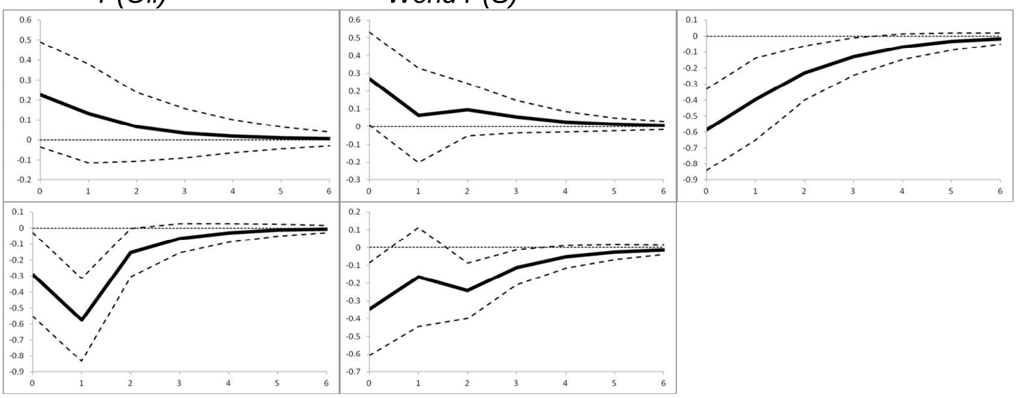
*P(Oil)* *World P(S)*



*Response of Russia:*

*Belarus* *Ukraine* *Russia P(S)*

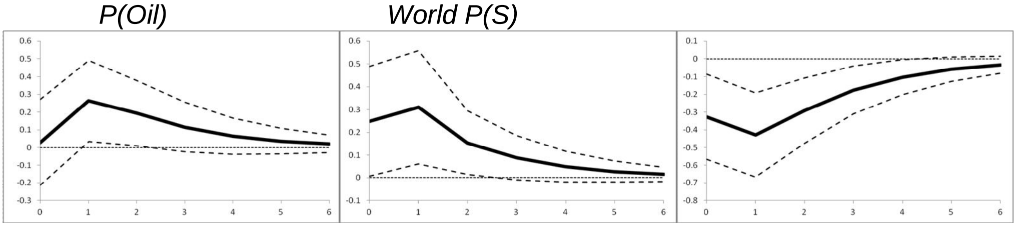
*P(Oil)* *World P(S)*

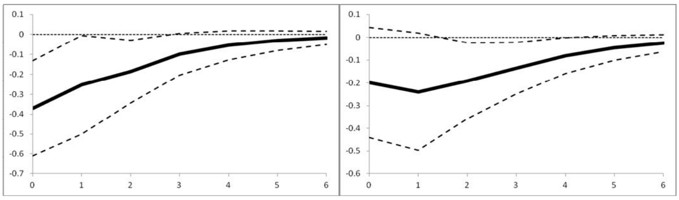


*Response of Ukraine:*

*Belarus* *Russia* *Russia P(S)*

*P(Oil)* *World P(S)*

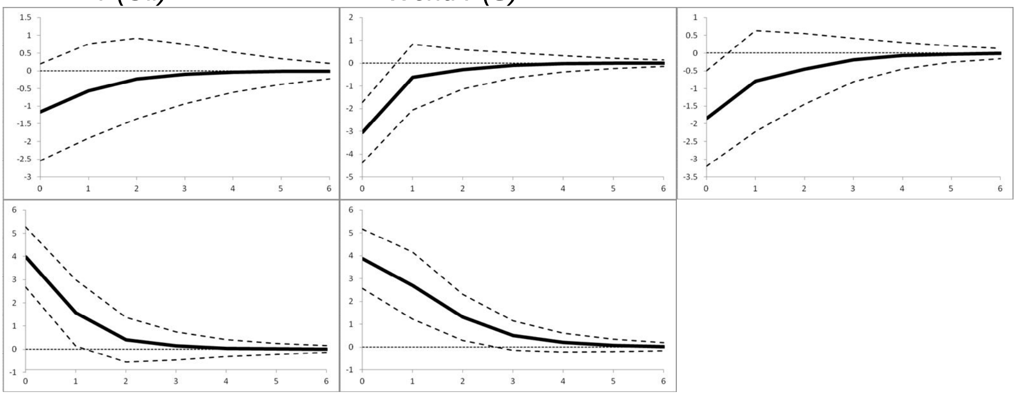




*Response of Russia P(S):*

*Belarus* *Russia* *Ukraine*

*P(Oil)* *World P(S)*

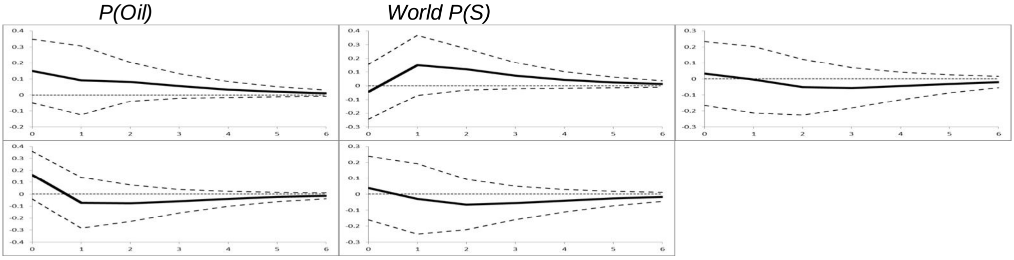


*ERW Measure, Effective*

*Response of Belarus:*

*Russia* *Ukraine* *Russia P(S)*

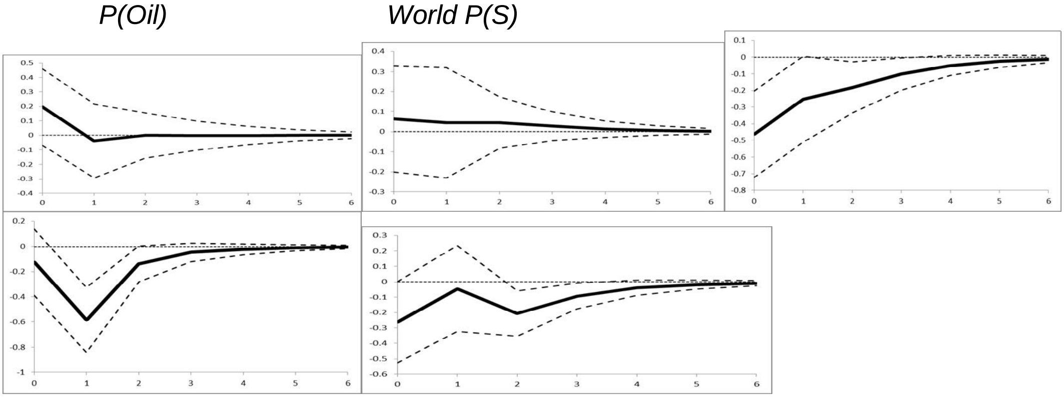
*P(Oil)* *World P(S)*



*Response of Russia:*

*Belarus* *Ukraine* *Russia P(S)*

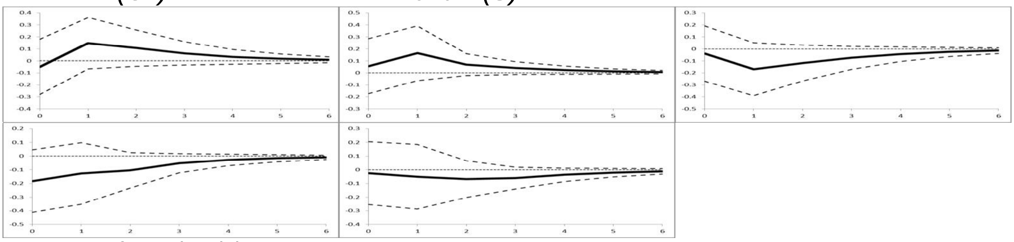
*P(Oil)* *World P(S)*



*Response of Ukraine:*

*Belarus* *Russia* *Russia P(S)*

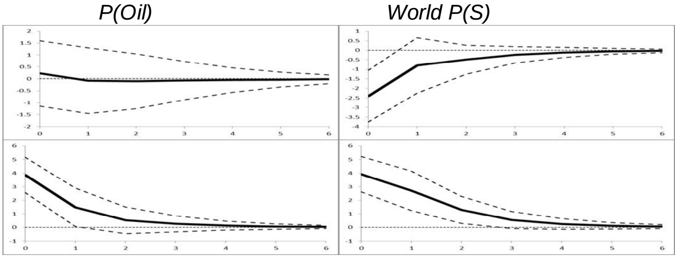
*P(Oil)* *World P(S)*



*Response of Russia P(S):*

*Belarus* *Russia* *Ukraine*

*P(Oil)* *World P(S)*

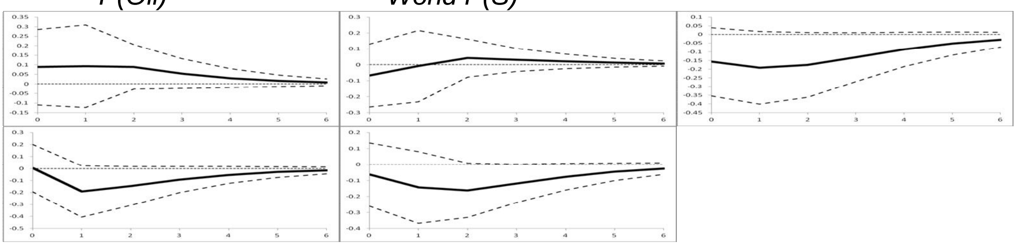


*PCA Measure, Bilateral*

*Response of Belarus:*

*Russia* *Ukraine* *Russia P(S)*

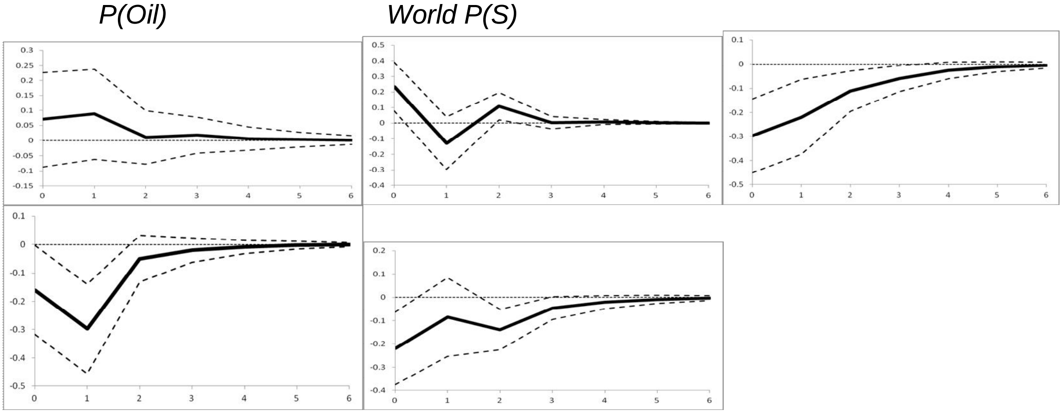
*P(Oil)* *World P(S)*



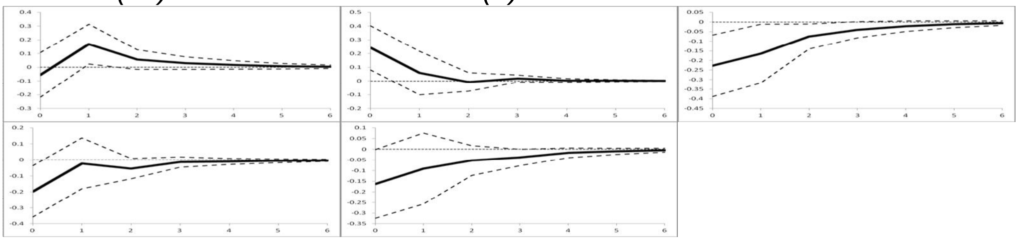
*Response of Russia:*

*Belarus* *Ukraine* *Russia P(S)*

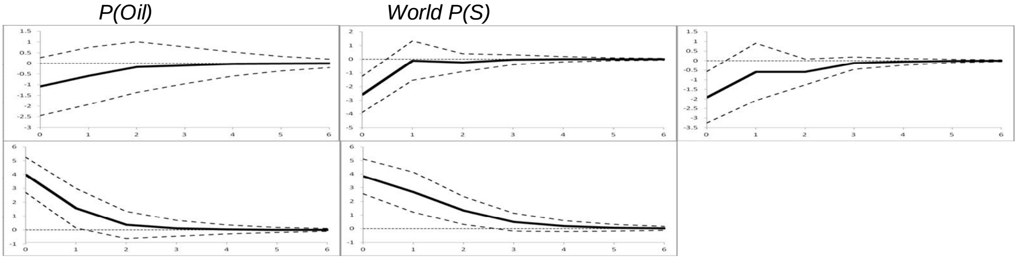
*P(Oil)* *World P(S)*



*Response of Ukraine:*
*Belarus* *Russia* *Russia P(S)*
*P(Oil)* *World P(S)*

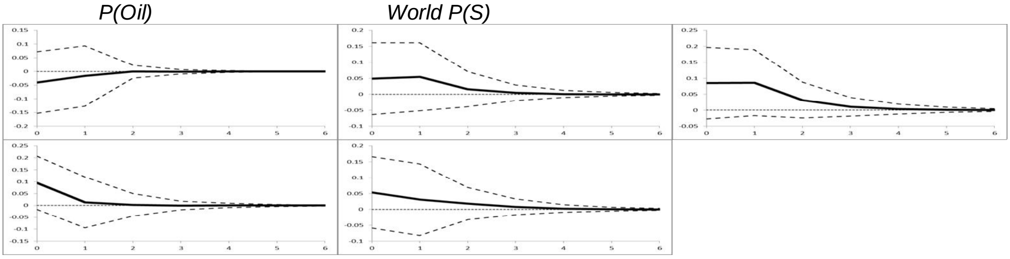


*Response of Russia P(S):*
*Belarus* *Russia* *Ukraine*
*P(Oil)* *World P(S)*

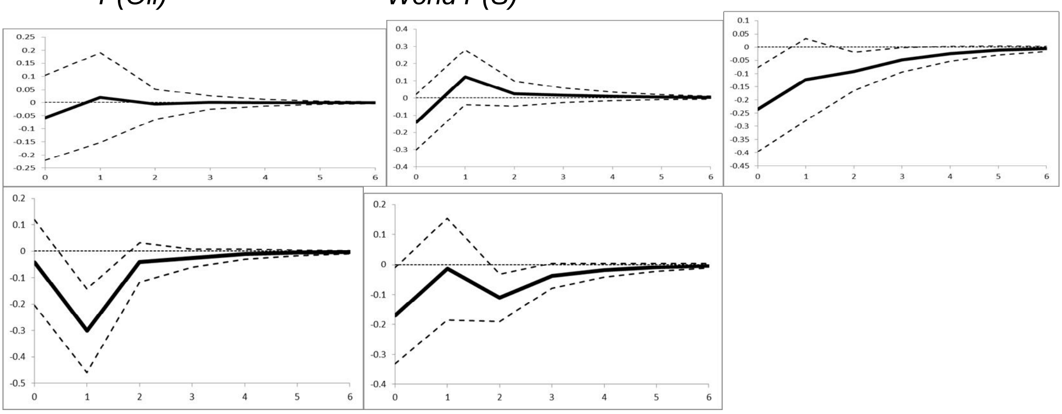


## *PCA Measure, Effective*

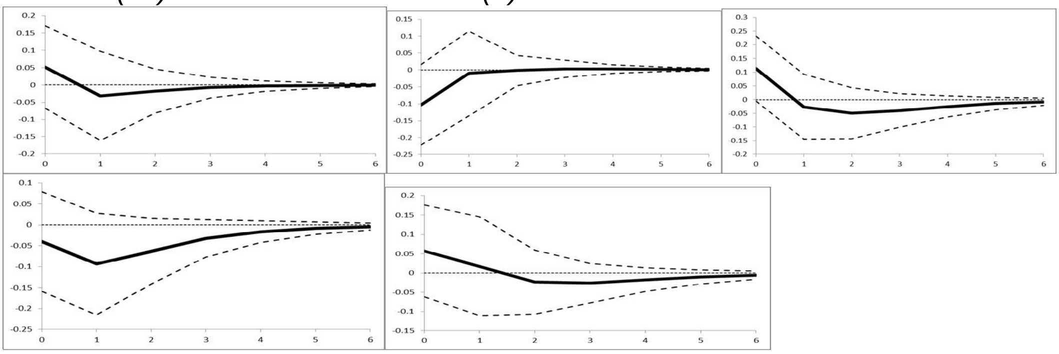
*Response of Belarus:*
*Russia* *Ukraine* *Russia P(S)*
*P(Oil)* *World P(S)*



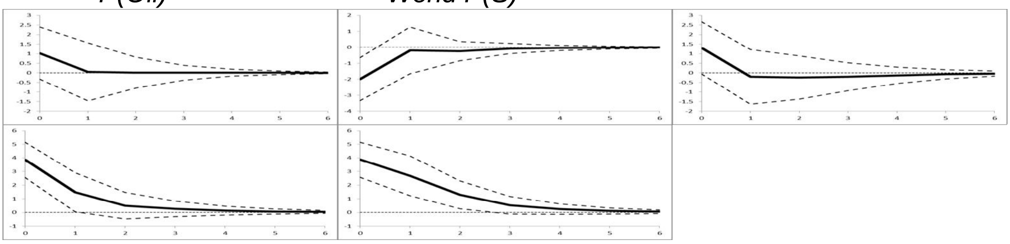
*Response of Russia:*
*Belarus* *Ukraine* *Russia P(S)*
*P(Oil)* *World P(S)*



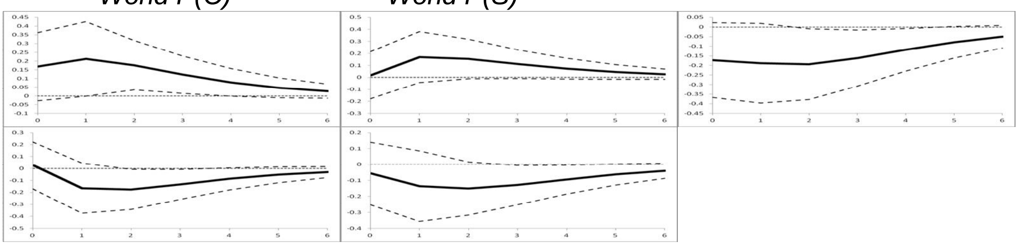
*Response of Ukraine:*
*Belarus* *Russia* *Russia P(S)*
*P(Oil)* *World P(S)*



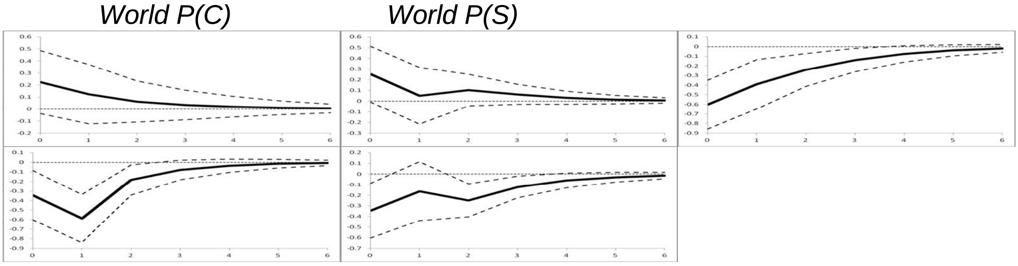
*Response of Russia P(S):*
*Belarus* *Russia* *Ukraine*
*P(Oil)* *World P(S)*



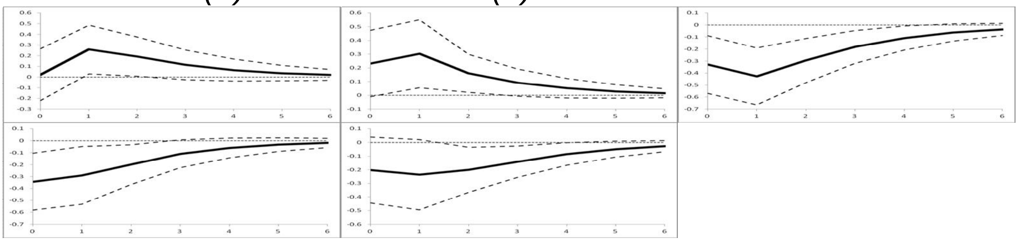
*ERW Measure, Bilateral, With World Commodity Prices*
*Response of Belarus:*
*Russia* *Ukraine* *Russia P(S)*
*World P(C)* *World P(S)*



*Response of Russia:*
*Belarus* *Ukraine* *Russia P(S)*
*World P(C)* *World P(S)*



*Response of Ukraine:*
*Belarus* *Russia* *Russia P(S)*
*World P(C)* *World P(S)*



*Response of Russia P(S):*
*Belarus* *Russia* *Ukraine*
*World P(C)* *World P(S)*