Sources of Real Exchange Rate Fluctuations in New EU Member States[1]

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Abstract

Fixed versus flexible exchange rate dilemma has become a subject of rigorous academic discussions for decades. Advantages of exchange rates flexibility contrasted benefits of exchange rate stability though a phenomenon known as the fear of floating favoured exchange rate variability and its positive effects on economies. Relative diversity in the exchange rate regimes in EU-11 countries motivated authors to investigate the sources of their real exchange rate volatility. However, fixed exchange rate perspective associated with Euro Area membership may induce changed patterns in the real exchange rate determination in countries that benefit from nominal exchange rate flexibility prior to Euro adoption. In the paper we analyse sources of real exchange rates fluctuations in EU-11 countries by employing SVAR methodology and computation of impulse-response functions. Our results indicate an increased responsiveness of real exchange rates in Euro Area non-member states to demand and supply shocks, particularly due to the effects of the crisis period. At the same time, real exchange rates in Euro Area member states from EU-11 group became more responsive to nominal shocks.

Keywords: *real exchange rates, exogenous shocks, economic crisis, structural vector autoregression, impulse-response function*

JEL Classification: C32, E52

Introduction

Economic crisis has induced diverse and spurious effects on current accounts adjustments in the individual Euro Area member states. However, Intra-Euro Area imbalances (Canale and Marani, 2015), as one of the key implications of the Euro Area design failures (De Grauwe, 2013), have clearly improved due to intensified redistributive effects of the crisis period (Chen, Milesi-Ferretti and Tressel, 2012). A changed composition of aggregate demand and associated

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cross-country expenditure shifting effects are generally recognized as the most crucial drivers of reduced external imbalances (Cingolani, Felice and Tajoli, 2015). However, some authors (Huchet-Bourdon and Korinek, 2011) argue that the crisis period deteriorated competitiveness of most of the Euro Area member states. As a result, incentives to increase external demand during the crisis period started an unfavourable spiral of competitive internal devaluations. At the same time, their real exchange rates have become more volatile (Wang et al., 2015) as a result of changed behaviour of structural shocks affecting real exchange rates path during the crisis period (Giannellis and Papadopoulos, 2011).

Negative effects of exchange rate instability on investments and trade had represented one of the key reasons for monetary integration in Europe (Stančík, 2006). The issues associated with heterogeneity among member states of the Euro Area and low levels in business cycles synchronization revealed different patterns in their real exchange rate determination (Darvas and Szapáry, 2008) fuelling the phenomenon of intra-Euro Area imbalances (Sipko, 2014). However, many authors argue (i.e. Fidrmuc and Korhonen, 2001) that there exists relatively high correlation of the underlying structural shocks between Euro Area and new EU member states (EU-112) promoting benefits of Euro Area enlargement. On the other hand, Ben Arfa (2009) revealed distortionary effects of asymmetry in supply shocks between the Euro Area and 12 CEECs (Central and Eastern European Countries) favouring a more consistent harmonisation of the economic policies.

Nowadays, five of EU-11 countries had already adopted Euro. While Baltic countries have employed an exchange rate targeting and operated in the fixed exchange rate environment before entering the Euro Area, Slovak Republic and Slovenia employed a managed floating. As of Euro Area non-members, only Bulgaria relies on exchange rate targeting while the remaining five countries enjoy the exchange rate flexibility. The existing diversity in the exchange rate arrangements among EU-11 countries is associated with relatively different effects of the real exchange rate volatility on a real output reducing eligible synchronization of business cycles between Euro Area member and non-member states (Mirdala, 2013). Moreover, the relative contribution of exogenous shocks to the real exchange rate volatility under fixed and flexible exchange rates clearly differs (Berka, Devereux and Engel, 2012). As a result, the process of further Euro Area enlargement may affect the responsiveness of real exchange rates to sudden shocks in those EU-11 countries that currently benefit from the exchange rate flexibility. In such a case, diverse effects on their external and internal competitiveness will

[2] Following countries are included in the sample of new EU member states (EU-11): Bulgaria, Czech Republic, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia.

raise the heterogeneity problem in the Euro Area and further fuel the phenomenon of intra-Euro Area imbalances.

In the paper we analyse sources of exchange rate fluctuations in EU-11 countries. Our approach is based on structural vector autoregression (SVAR) methodology. We calculate responses of real exchange rates to the one standard deviation supply, demand and nominal shocks. SVAR models will be estimated for each country from EU-11 group for two periods: 2000 – 2007 (pre-crisis period) and 2000 – 2014 (extended period). The idea is to examine the effects of the crisis period on estimated results. The comparison of results for Euro Area members and non-members will provide crucial evidence on the real exchange rate determination and its absorption capabilities, especially in terms of fixed versus flexible exchange rate dilemma. Our results indicate an increased responsiveness of real exchange rates in Euro Area non-member states to demand and supply shocks, particularly due to the effects of the crisis period. At the same time the real exchange rates in Euro Area member states have become more responsive to nominal shocks.

1. Overview of the Literature

Empirical studies examining the responses of exchange rates on structural shocks are usually based on SVAR methodology. Structural shocks are obviously identified by imposing long-run (rarely short-run) neutrality restrictions on the unrestricted VAR (vector autoregressive) model. The forces that affect a real exchange rate path are thereafter decomposed into temporary and permanent ones.

Kutan and Dibooglu (2001) analysed the sources of exchange rates volatility in Hungary and Poland by examining a relative contribution of nominal and real shocks to the real and nominal exchange rate fluctuations. Their findings indicate the distortionary effects of both shocks, especially on real exchange rates determination. Hamori and Hamori (2007) analysed the sources (supply, demand and nominal shocks) of nominal and real Euro exchange rate movements. The authors emphasize a dominant role of a real shock on the real exchange rate in the long-run and even its overshooting effect. They also confirmed just a temporary effect of the nominal shock on the real exchange rate together with its long-run neutrality. Stazka (2006) examined the sources of real exchange rates volatility on a sample of nine CEECs. Her findings confirm that the absorption capabilities of real exchange rates according to the effects of asymmetric shocks largely depend on exchange rate arrangement in a particular country. Chowdhury (2004) investigated sources (real and nominal shocks) of bilateral exchange rates fluctuations in the selected developing countries vis-à-vis USD. Author stressed a crucial role of the number of lags (time dimension) in explaining the particular importance of individual structural shocks hitting the real exchange rates. He also provides

the evidence that real shocks dominate the nominal shocks for the exchange rate series examined. Enders and Bong-Soo (1997) decomposed sources of real and nominal exchange rates movements to real and nominal components focusing on bilateral exchange rates USD/CAD a JPY/DEM. The authors highlight a crucial role of a demand shock and distortionary effects of supply shocks on the real exchange rates during the most of examined period. Lastrapes (1992) analysed sources (nominal and real shocks) of the real and nominal exchange rates fluctuations in U.S.A., Germany, Great Britain, Japan, Italy and Canada. The findings indicate that real shocks dominate nominal shocks for both nominal and real exchange rates over short and long frequencies. Giannellis and Papadopulos (2011) examined the sources of exchange rate volatility in selected Euro Area and non-Euro Area countries (Central and Eastern Europe – CEE) by employing GARCH (Generalized Autoregressive Conditional Heteroskedasticity) and VAR methodology supplemented by Granger causality. The authors emphasize that the exchange rates in CEE have the same source of volatility (i.e. monetary shocks) favouring common monetary policy that could treat their real exchange rates volatility (supporting argument for Euro Area enlargement). However, the results seem to be time varying.

2. Exchange Rate Arrangements in New EU Member States

Exchange rate regimes diversity in new EU member states has revealed uncertain and spurious conclusions about the exchange rate regime choice during the last two decades (Calvo and Reinhart, 2002). Moreover, Euro Area membership perspective (de jure pegging to Euro) has highlighted uncertain consequences of the exchange rate regime switching especially in the countries with large economies and flexible exchange rate arrangements.

The new EU member states did not follow common practice in the process of the exchange rate regime choice at the beginning of the 1990s (Table 1). Small Baltic countries had adopted a currency board regime (Estonia and Lithuania) eventually a conventional fixed peg regime (Latvia). Hungary had adopted a crawling peg regime (after few years of adjustable peg in place) together with Poland. Czech Republic and Slovak Republic had adopted a pegged regime with horizontal bands. Despite high inflation rates, Bulgaria, Croatia, Romania and Slovenia had adopted a floating exchange rate regime due to low level of reserves and a lack of credibility though Bulgaria switched to currency board after 1996 – 1997 financial crisis. Most of new EU member states had enjoyed disinflationary and credibility benefits of so called hard or soft pegged exchange rate regimes (Frait and Komárek, 2001). Fixed exchange rates as the nominal anchor had significantly contributed to the successful disinflationary process at the end of the 1990s.

Table 1

Exchange Rate Regimes in New EU Member States

	Exchange rate regime																									
Bulgaria		managed floating							currency board																	
Czech Republic	peg with horizontal bands								managed floating																	
Croatia		crawling peg	managed floating																							
Estonia		currency board													ERM2						Euro Area					
Hungary	adjustable peg				crawling peg						peg with horizontal bands								managed floating							
Latvia		floating	conventional fixed peg													ERM2							Euro Area			
Lithuania		floating	currency board												ERM2										Euro Area	
Poland		crawling peg										free floating														
Romania	free floating								managed floating																	
Slovak Republic	peg with horizontal bands									managed floating						ERM2			Euro Area							
Slovenia		managed floating											crawling band			ERM2		Euro Area								
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**

Note: Exchange rate regime evolution in the New EU member states (based of IMF de jure classification): ***Bulgaria*** – since 1991 floating (pegged exchange rate regime undesirable due to possible low credibility), currency board since 1997 (after 1996 – 1997 financial crisis – public debt, bad commercial banks loans); ***Czech Republic*** – exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since May 1997 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency; ***Croatia*** – crawling peg since March 1992 till October 1993, since October 1993 tightly managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency; ***Estonia*** – currency board since 1992 till 2011 (Euro adoption), plan to adopt in 2008 but delayed due high inflation, since 2011 Eurozone membership; ***Hungary*** – managed floating till February 1995, since March 1995 till the end of 1999 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since January 2000 exchange rate pegged to Euro combined with wide horizontal bands (since May 2001), since May 2008 managed floating with EUR as reference currency; ***Latvia*** – since February 1994 exchange rate pegged to SDR (fixing the exchange rate to a basket of currencies (SDR) instead of a single currency serves to promote long-term stability) (since January 2005 pegged to EUR), since 2014 Eurozone membership; ***Lithuania*** – since April 1994 currency board (exchange rate pegged to USD, in February 2002 pegging switched to EUR), since 2015 Eurozone membership; ***Poland*** – since the end of 1991 crawling peg with continuously decreased rate of periodical devaluation and widen horizontal bands, since April 2000 free floating; ***Romania*** – free floating, since 1998 exchange rate arrangement reclassified as managed floating; ***Slovak Republic*** – exchange rate pegged to currency basket with narrow but continuously widen horizontal bands, since October 1998 after currency attacks switch to managed floating with no predetermined path for the exchange rate with DEM (EUR) as reference currency, since 2009 Eurozone membership; ***Slovenia*** – managed floating with no predetermined path for the exchange rate (since February 2002 crawling band – the monetary authority manages the float of the domestic currency within certain fluctuating margins around a depreciating path – a heavily-managed crawling band with pragmatic monetary, real, external and financial indicators). ERM2 – June 2004 – Estonia (left in January 2011 after Euro adoption), Lithuania (left in January 2015 after Euro adoption), Slovenia (left in January 2007 after Euro adoption); – May 2005 – Latvia (left in January 2014 after Euro adoption); – November 2005 – Slovak Republic (left in January 2009 after Euro adoption).

Source: IMF AREAER 1990 – 2014; author's processing.

By the end of the decade many countries from the group had switched to the more flexible exchange rate regimes (Czech Republic in 1997, Slovak Republic in 1998, and Poland in 2000). Similarly Hungary switched to an intermediate regime by the widening of horizontal bands. Although Hungary stacked to an exchange rate pegged to Euro, by employing wide horizontal bands de facto followed the same trend as previous group of countries.

New EU member states challenged a decision of a Euro adoption and Euro Area membership several years before the economic crisis arises (Hedija, 2013). Disputable policy implications of sacrificing monetary sovereignty had risen as a crucial assumption affecting the main features as well as durability of preparation phase timetable in countries with the flexible exchange rate regimes (Czech Republic, Croatia, Poland, Romania, Slovak Republic and Slovenia). Among a variety of determinants and aspects we emphasize the role of decisions inevitably associated with a "proper" scheduling of the Euro Area entry. Some countries from the group of new EU member states already entered the Euro Area (Slovenia – 2007, Slovak Republic – 2009, Estonia – 2011, Latvia – 2014, Lithuania – 2015) followed by participation of their currencies in ERM2 (Estonia – June 2004, Lithuania – June 2004, Slovenia – June 2004, Latvia – May 2005, Slovak Republic – November 2005).

The economic theory provides clear suggestions in a fixed versus flexible exchange rates dilemma in terms of the exchange rate based adjustments in the external competitiveness as well as external and internal shocks absorption capabilities of the exchange rate. From the perspective of a macroeconomic stabilization, the costs or benefits of giving up the flexible exchange rate depends on the types of asymmetric shocks hitting the economy and the ability of the exchange rate to act as a shock absorber. Borghijs and Kuijs (2004) argue that flexible exchange rates are useful in absorbing asymmetric real shocks but unhelpful in the case of monetary and financial shocks.

Even before Euro Area establishment some authors (Bayoumi and Eichengreen, 1992) had argued that structural shocks are significantly idiosyncratic across EU countries suggesting difficulties in operating a monetary union. Moreover, the existing heterogeneity among Euro Area members operating under the fixed exchange rates is still being associated with the asynchronous real exchange rates adjustments based on price (wage) differentials affecting their equilibrium levels in the long-run (Égert, Halpern and MacDonald, 2005). Among the key lessons learned from the latest economic crisis is an increased dynamic in the real exchange rate volatility among the Euro Area member states as well as non-member states (Berka, Devereux and Engel, 2012) recognized as a side effect of waves of internal devaluations (Angelini, Dieppe and Pierluigi,

2015). Central banks and governments, especially under the fixed exchange rate anchor, may tend to internally devaluate currencies in times when a low interest rates policy associated with a quantitative easing does not provide correct and sufficient incentives to boost domestic demand. At the same time, incentives to increase external demand during the crisis period may start an unfavourable spiral of competitive devaluations. Finally, the crisis period has affected responsiveness patterns of the real exchange rates to underlying shocks in both Euro Area member and non-member states (Grossmann, Love and Orlov, 2014). As a result, our motivation to examine the role of real exchange rates as a shock absorber or source of underlying shocks (Artis and Ehrman, 2000) under the fixed and flexible nominal exchange rates involves the effects of the crisis period as well.

3. Econometric Model

We examine sources of the real exchange rate volatility in EU-11 countries using SVAR methodology introduced by Clarida and Gali (1994), which implements the long-run identifying restrictions to the unrestricted VAR models pioneered by Blanchard and Quah (1989). VAR models represent the dynamic systems of equations in which the current level of each variable depends on its past movements as well as all other variables involved in the system.

If $\mathbf{X}_t$ is covariance stationary then an unrestricted form of the VAR model will have the following infinite moving average representation:

$$\mathbf{A}\mathbf{X}_t = \mathbf{B}(L)\mathbf{X}_{t-1} + \mathbf{B}\varepsilon_t \tag{1}$$

where

$\mathbf{X}_t = \left[y_{r,t}, er_{r,t}, er_{n,t} \right]$ represents k x 1 a vector of endogenous variables (in our trivariate model we consider following endogenous variables),

$y_{r,t}$ – real output,

$er_{r,t}$ – real exchange rate,

$er_{n,t}$ – nominal exchange rate),

$\mathbf{B}(L)$ – k x k polynomial consisting of the matrices of coefficients to be estimated in the lag operator L representing the relationship among variables on the lagged values, each of $\mathbf{A}$ and $\mathbf{B}$ represent k x k matrix which coefficients will be specified later,

ε_t – denote k x 1 vector of identically normally distributed, serially uncorrelated and mutually orthogonal errors (white noise disturbances that represent the unexplained movements in the variables, reflecting the influence of exogenous shocks):

$$E(\varepsilon_t)=0, \quad E(\varepsilon_t\varepsilon_t')=\Sigma_\varepsilon=\mathrm{I}, \quad E(\varepsilon_t\varepsilon_s') = [0] \quad \forall t\neq s \tag{2}$$

Residuals of vector ε_t represent unexplained movements in variables (the effects of exogenous shocks hitting the model); however as complex functions of structural shocks effects they have no economic interpretation. Structural shocks can be still recovered using a transformation of the true form representation into the reduced-form by imposing a number of identifying restrictions. The applied restrictions should reflect some general assumptions about the underlying structure of the economy and they are obviously derived from the economic theory (Faust and Leeper, 1994). However, the restrictions based on theoretical assumptions should be empirically tested to avoid shocks identification bias and imprecisions associated with the endogenous variables responses to the shocks. We assume three exogenous shocks that contemporaneously affect endogenous variables – supply shock[3] $(\varepsilon_{s,t})$, demand shock[4] $(\varepsilon_{d,t})$ and nominal shock[5] $(\varepsilon_{n,t})$.

Structural exogenous shocks from equation (1) are not directly observable due to the complexity of information included in true form VAR residuals. As a result, the structural shocks cannot by correctly identified. If **A** is invertible, it is necessary to transform the true model into the following reduced form

$$\mathbf{X}_t = \mathbf{A}^{-1}\mathbf{B}(L)\mathbf{X}_{t-1} + \mathbf{A}^{-1}\mathbf{B}\varepsilon_t = \mathbf{C}(L)\mathbf{X}_{t-1} + e_t \tag{3}$$

where

$\mathbf{C}(L)$ – the polynomial of matrices with coefficients representing the relationship among variables on lagged values and the disturbance term;

e_t – denote k x 1 vector of normally distributed errors (shocks in reduced form) that are serially uncorrelated but not necessarily orthogonal (shocks in the reduced form can be contemporaneously correlated with each other):

$$E(e_t)=0, \quad \Sigma_u=E(e_te_t')=\mathbf{A}_0E(e_te_t')\mathbf{A}_0'=\mathbf{A}_0\mathbf{A}_0', \quad E(e_te_s') = [0] \quad \forall t\neq s \tag{4}$$

The relationship between reduced-form VAR residuals (e_t) and structural shocks (ε_t) can be expressed as follows:

$$e_t = A^{-1}B\varepsilon_t \quad \text{or} \quad Ae_t = B\varepsilon_t \tag{5}$$

[3] *Supply shock* is generally represented by i.e. unexpected shifts in productivity, labor market shocks, changes in the prices of key inputs, etc.

[4] *Demand shock* is generally represented by i.e. unexpected shifts in exports, government expenditures, etc.

[5] *Nominal shock*, also known as monetary or currency shock, is generally represented by i.e. changes in money supply and liquidity preference, velocity of money, risk premium, effects induced by financial liberalization, speculative currency attacks, etc.

SVAR methodology decomposes the series into its permanent and temporary components. The identification scheme of VAR model then affects properties of a matrix **A**. The identification of matrix **A** requires a definition of k^2 elements (i.e. 9 restrictions). We begin with $k(k + 1)/2$ restrictions imposed on the covariance matrix (i.e. 6 restrictions). The first three restrictions (summarized in equation (2)) we obtain from the assumption that each of the shock has a unit variance – it is nothing but a convenient normalization (standard deviations of the shocks are normalized to one; $\mathrm{var}(\varepsilon) = 1$). Another three restrictions are given by the assumptions that structural shocks are mutually orthogonal (uncorrelated). The last 3 restrictions come from the long-run neutrality properties. It is expected that the cumulative effect of a particular shock on some endogenous variables is zero. Matrix **B** is identity matrix so that the off-diagonal elements of **B** are all zero, implying that we do not allow structural shocks to be mutually correlated.

The framework of our model implies that only a supply shock has permanent effect on all endogenous variables. Demand shock has permanent effect on the real and nominal exchange rate while its impact on the real output is just temporary. The nominal shock has permanent effect only on the nominal exchange rate while its impact on the real exchange rate and the real output is considered as temporary. The identification of temporary effects of identified structural shocks on endogenous variables is represented in the model by the following long-run (neutrality) restrictions

$$\sum_{i=0}^{\infty} a_{12i} = 0,\ \sum_{i=0}^{\infty} a_{13i} = 0,\ \sum_{i=0}^{\infty} a_{23i} = 0 \tag{6}$$

The equation (5) can be now rewritten to the following form:

$$\begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{32} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} e_{y_r,t} \\ e_{er_n,t} \\ e_{er_r,t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{s,t} \\ \varepsilon_{d,t} \\ \varepsilon_{n,t} \end{bmatrix} \tag{7}$$

The system is now just-identified. From estimated SVAR model we compute impulse-response functions of real exchange rate to analyse its responsiveness to the underlying supply, demand and nominal shocks in EU-11 countries.

If the exogenous structural shocks are correctly identified, we might expect the following results (Alexius and Post, 2005; Rogers, 1999):

- The effect of a positive supply shock to nominal and real exchange rates is ambiguous in the short-run, while in the long-run we expect an ambiguous response only for real exchange rate.

- The positive demand shock appreciates both nominal and real exchange rates in the short-run. If the shock is permanent, the real exchange rate should appreciate after the positive demand shock in the long-run.
- In the short-run the positive nominal shock is followed by the depreciation of both nominal and real exchange rates. The shock has no effect on real exchange rate in the long-run.

4. Data and Results

We estimate trivariate SVAR model for EU-11 countries to estimate the responsiveness of real exchange rates in EU-11 countries to the positive one standard deviation supply, demand and nominal shocks. Monthly data for the period of 2000M1 – 2007M12 (model A) consisting of 96 observations and for the period of 2000M1 – 2014M12 (model B) consisting of 180 observations were employed for the following endogenous variables - industrial production[6] (nominal volume of seasonally adjusted industrial production deflated by averaged CPI – Consumer Price Index), nominal exchange rate (Nominal Effective Exchange Rate – NEER) and real exchange rate (Real Effective Exchange Rate – REER calculated on CPI base). Time series for all endogenous variables were collected from IMF database (IMF, 2015).

The stationarity of VAR model was checked using the augmented Dickey--Fuller (ADF) and Phillips-Perron (PP) tests. Both tests had indicated that all the variables are non-stationary on the values indicating that the null hypothesis of a unit root presence cannot be rejected for any of time series. Tests of variables in first differences indicate that time series are stationary. We may conclude that variables are I(1).

Because all endogenous variables have a unit root it is necessary to test time series for cointegration using the Johansen and Juselius cointegration test. The test for the cointegration was calculated using two lags as recommended by the AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion).

The results of Johansen and Juselius cointegration tests confirmed that our non-stationary series do not contain a common stochastic trend. Both the trace statistics and maximum eigenvalue statistics (both at 0.05 level) indicate that there is no cointegration among endogenous variables of the model.

To test the stability of VAR models we have also employed a number of diagnostic tests. We have found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in disturbances.

[6] Time series for monthly industrial production were employed due to absence of data on the same basis for real output (GDP) that is available on quarterly basis only.

The model also passed the Jarque-Bera normality test, so that errors seem to be normally distributed. Moreover, VAR models seem to be stable as the inverted roots of the model for each country lie inside the unit circle (i.e. all eigenvalues of A have modulus less than one). As a result, if $\mathbf{X}_t$ has an invertible moving average representation, it also has a stable VAR structure. The detailed results of time series testing procedures are not reported here to save the space. Like any other results, they are available upon request from the author.

In terms of results of the unit root and cointegration tests we have estimated the model using variables in the first differences so that we can calculate impulse--response functions for all EU-11 countries. Following the main objective of the paper we discuss the responses of real exchange rates to the positive one standard deviation supply, demand and nominal shocks. We expect that the responsiveness of real exchange rates may differ according to the underlying exchange rate arrangement employed by an individual country. Due to existing diversity in the exchange rate regimes in EU-11 during the pre-ERM2 period (rigid versus flexible exchange rate regimes) we divide EU-11 countries in two big groups – "peggers" (Bulgaria, Estonia, Latvia, Lithuania) and "floaters" (Croatia, Czech Republic, Hungary,[7] Poland, Romania, Slovak Republic, Slovenia).

We also discuss the effects of economic crisis on the real exchange rates fluctuations in EU-11 countries by comparing the results for models with two different periods – model A (2000M1 – 2007M12) and model B (2000M1 – 2014M12). When applicable, we also examine the effects of exchange rate regime shifts in the countries with flexible exchange rate regimes (Slovak republic and Slovenia) prior to the Euro Area membership.

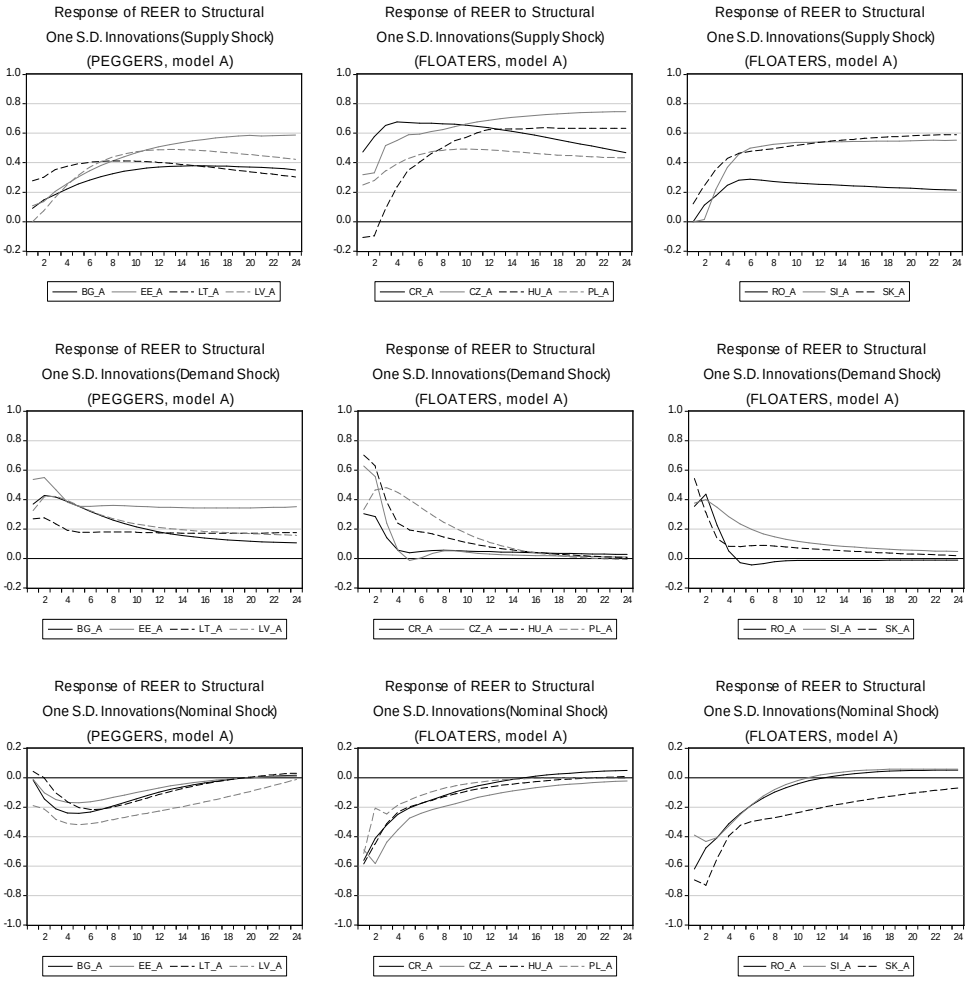
In Figure 1 we summarize the estimated responses of real exchange rates to the positive one standard deviation supply, demand and nominal shocks in EU-11 countries during the pre-crisis period (model A). While the real exchange rates responses correspond to our general expectations, we have observed different patterns in the real exchange rates responsiveness to the underlying exogenous shocks in individual countries.

Supply shock caused real exchange rate appreciation in all 11 countries. However, real exchange rates in the group of "floaters" were generally more sensitive to the supply shock in the short-run (especially in first 12 months). Positive effect of the supply shock was even stronger in small and more opened economies. The overall effect of the supply shock in both groups of countries was quite durable, though neutral in the long-run as its effect died out in all 11 countries in the long-term period.

[7] Hungarian forint operated during pre-crisis period in de facto fixed peg regime, but due to substantial range for fluctuations provided by wide horizontal bands it was included in the group of countries, so called "floaters".

F i g u r e 1

Responses of Real Exchange Rates to Structural Shocks (2000M1 – 2007M12)



Note: Curves represent responses (changes in percentage) of real exchange rates to the one standard deviation positive structural shocks in each individual country from the EU-11 group. All shocks are standardized to one-percent shocks. Horizontal axis depict months.

Source: Author's calculations.

Real exchange rates increased (appreciated) in both groups of countries after the unexpected *demand shock*. However, the overall responsiveness of real exchange rates in the countries from the group of "peggers" was generally higher in the medium and long term period. Moreover, the effect of the demand shock seems to be permanent in Estonia and Lithuania (the real exchange rate remained appreciated even in the long-run). Real exchange rates in the countries from the

group of “floaters” experienced just a short-term vulnerability to the demand shock as the significant part of its effect died out within first year after the shock.

Finally, real exchange rates decreased (depreciated) after the positive *nominal shock* in all EU-11 countries. High exposure to the shock in the short-term period was experienced by countries from the group of “floaters”. Their real exchange rates immediately depreciated though the negative effect of the shock was just a temporary and the substantial part of its effect died out within the following 12 – 24 months. Much lower immediate and short-term negative effect of the unexpected nominal shock experienced the real exchange rates in the countries from the group of “peggers”. Long-run effect of the nominal shock on the real exchange rates in both groups of countries was just temporary and thus neutral in the long-run period.

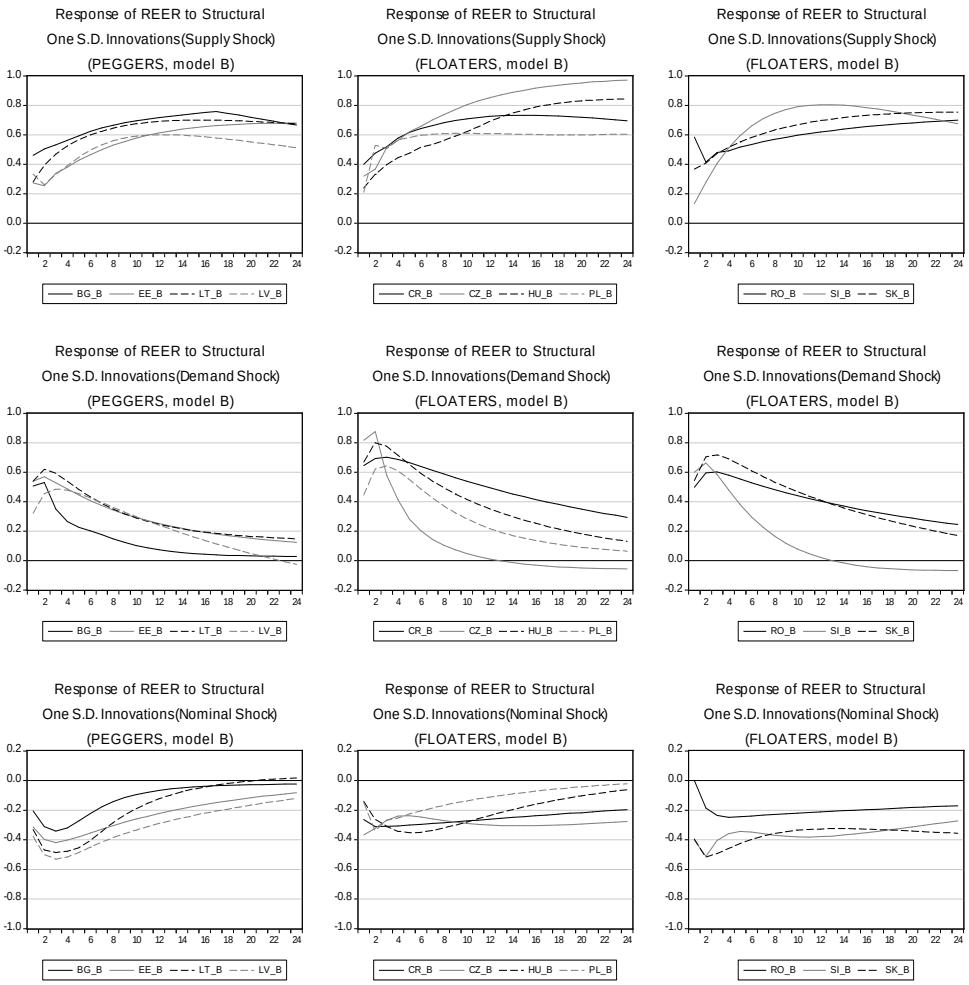
Real exchange rate responsiveness to the unexpected exogenous shocks in both groups of the countries during the pre-crisis period revealed some crucial implications of the exchange rate regimes diversity. The immediate real exchange rate adjustments followed by all three types of structural shocks were generally lower in the countries with rigid exchange rate arrangements. However, the leading path of responses and related durable convergence of the real exchange rates to their pre-shock levels make absorption capabilities of the real exchange rates (measured by the speed of convergence to the pre-shock level) in EU-11 countries with rigid regimes disputable. At the same time, we highlight the short-term (within first 12 months) absorption capabilities of real exchange rates in the countries with flexible exchange rate regimes. However, the real exchange rates in both groups of the countries are quite vulnerable to the supply shocks, especially in the medium-term period.

In Figure 2 we summarize the estimated responses of real exchange rates to the positive one standard deviation supply, demand and nominal shocks in EU-11 countries during the extended period (model B). While the real exchange rates responses correspond to our general expectations, we have observed different patterns in the real exchange rates responsiveness to the underlying exogenous shocks in individual countries.

Crisis period affected the leading path of the real exchange responses to the unexpected positive structural shocks in both groups of countries. All the countries experienced an increased responsiveness of their real exchange rates to the *supply shock* thought the effect was more obvious in the countries with flexible exchange rate arrangements. The positive effect of the shock on the real exchange rates was even more durable. However, the positive effect of the supply shock in Slovak Republic and Slovenia (both countries operated under Euro Area during the whole crisis period) on their real exchange rates was less obvious.

F i g u r e 2

Responses of Real Exchange Rates to Structural Shocks (2000M1 – 2014M12)



Note: Curves represent responses (changes in percentage) of real exchange rates to the one standard deviation positive structural shocks in each individual country from the EU-11 group. All shocks are standardized to one-percent shocks. Horizontal axis depict months.

Source: Author's calculations.

Similarly, the overall vulnerability of real exchange rates to the positive *demand shock* increased in both groups of countries. However, the increased immediate and short-term intensity and durability of the shock is clearly more visible in countries with flexible exchange rate arrangements.

Response patterns of the real exchange rates to the positive *nominal shocks* followed different scenario in comparison with two previous shocks. While short-term responsiveness of the real exchange rates to the nominal shocks

increased in both groups of the countries, the immediate effects of the shock were clearly higher in the countries with the rigid exchange rate regimes.

The effects of all exogenous shocks on real exchange rates in EU-11 countries during the extended period were just temporary and thus neutral in the long-run period.

Our results for the extended period indicate the increased responsiveness and thus reduced absorption capabilities of real exchange rates in both groups of the countries. However, the overall dynamics of the real exchange rate adjustments followed by unexpected structural shocks was clearly higher in countries with flexible exchange rate arrangements which correspond with both theoretical assumptions and empirical evidence. However, the overall vulnerability of the real exchange rates in the countries with rigid exchange rate arrangements to the effects of nominal shocks significantly increased during the crisis period. Similar results were observed for Slovak Republic and Slovenia (both countries operated under Euro Area during the whole crisis period) as the vulnerability of their real exchange rates to the nominal shock was the highest from the whole group of "floaters".

Conclusion

In the paper we have analysed sources of real exchange rate fluctuations in EU-11 countries. Our results indicate that exogenous structural shocks have determined real exchange rates in countries with rigid and flexible exchange rate regimes in line with the general empirical investigations. However, we have observed interesting implications and related distortionary effects of structural shocks during the crisis period causing excessive exchange rate adjustments that may be the subject of further academic discussion focusing on unique implications of economic crisis.

Our results also indicate that the real exchange rate determination is sensitive to the exchange rate regimes diversity. Reduced immediate responsiveness of real exchange rates to all three types of exogenous shocks in countries with rigid exchange rate arrangements provides a supportive evidence for positive implications of higher immediate absorption capabilities of fixed exchange rates. However, relatively low speed of the real exchange rate convergence toward pre-shock levels makes absorption capabilities of real exchange rates in EU-11 countries with fixed exchange rate regimes disputable.

Increased responsiveness of real exchange rates during the extended period indicate reduced absorption capabilities of real exchange rates in both groups of countries. This implies that countries with fixed exchange rates ("peggers") have

experienced intensified internal price based adjustments during the crisis period fuelling the phenomenon of internal devaluation and risks associated with deflationary spiral. Moreover, risks associated with increased vulnerability of real exchange rates to nominal shocks under fixed exchange rates induces distortionary effects especially when considering exogenous monetary policy (Euro Area members) as the source of nominal shocks.

Real exchange rates in all EU-11 countries are quite vulnerable to the supply shocks in the long-run. As a result, increased competitiveness associated with positive technological shocks enable countries to offset price based increase in the international competitiveness and shift their exchange rates closer to the purchasing power parity. At the same time, high vulnerability of real exchange rates to the demand shocks in all countries (especially in the short-run and clearly higher under the nominal exchange rate flexibility) indicates that international competitiveness of EU-11 countries is highly vulnerable to sudden shifts aggregate demand components. As a result, higher exposure of international competitiveness to the unexpected demand shocks under nominal exchange rate flexibility (i.e. monetary sovereignty) even intensifies redistributive effects of the crisis in EU-11 countries outside the Euro Area. On the other hand, increased absorption capabilities of exchange rates in countries with nominal exchange rate anchor reduced possible competitiveness gains associated with exchange rate depreciation followed by negative demand shocks at the beginning of the crisis period. Increased persistency of nominal shocks in exchange rates determination in countries with flexible exchange rate arrangements during the crisis period should draw attention of the countries toward ERM2 membership. However, adoption of soft pegs may result in speculative attacks and forced devaluation (Stazka, 2006) or even forced revaluation (Amador et al., 2015) that is why we suggest that smaller economies from our sample would benefit more from their own independent currencies during the post-crisis recovery in the Euro Area.

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