# Sources of exchange rate dynamics in the European transition economies

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**Abstract**:

*Exchange rates in the European transition economies are currently exposed to the exogenous shocks as a result of higher uncertainty on the foreign exchange markets related to the various kinds of world economic crisis implications. Higher vulnerability of exchange rates of these countries to the exogenous shocks reflects decreased confidence of financial markets to the recovery process as well as an ability of the governments to sustain persisting fiscal pressures leading to higher fiscal deficits and public debt. Another issue that emphasizes the role of exogenous shocks in determining the exchange rate development in the European transition economies is the ability of national central banks to perform "suitable" monetary policy that would be able to support the recovery process in these economies while still being able to protect exchange rate of the national currency against speculative attacks and to keep exchange rate stable in the medium term horizon.*

*In the paper we analyze the sources of exchange rate movements in the European transition economies (Bulgaria, the Czech republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania) in the period 2000-2009 using SVAR (structural vector autoregression) approach applied on each country individual data as well as panel data. We decompose the variability of NEER and REER in these countries to permanent and temporary shocks. Impulse-response functions are also computed in order to estimate the behaviour of NEER and REER after structural one standard deviation innovations. The relevant outcomes of the analysis we compare with the results of the tests for the whole euro area (represented here by old EU member countries - EU-12 group). This approach helps us to understand the common as well as differing features of NEER and REER determination in the European transition economies and the old EU member countries.*

**Keywords:** exchange rates, exogenous shocks, structural vector autoregression, variance decomposition, impulse-response function, panel data analysis

**JEL Classification**: C32, E52

## 1. Introduction

Exchange rates in the European transition economies are currently exposed to the exogenous shocks as a result of higher uncertainty on the foreign exchange markets related to the various kinds of world economic crisis implications. Higher vulnerability of exchange rates of these countries to the exogenous shocks reflects decreased confidence of financial markets to the recovery process as well as an ability of the governments to sustain persisting fiscal pressures leading to higher fiscal deficits and public debt. Another issue that emphasizes the role of exogenous shocks in determining the exchange rate development in the European transition economies is the ability of national central banks to perform "suitable" monetary policy that would be able to support the recovery process in these economies while still being able to protect exchange rate of the national currency against speculative attacks and to keep exchange rate stable in the medium term horizon.

In the paper we analyze the sources of exchange rate movements in the European transition economies (Bulgaria, the Czech republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania) and euro area (represented here by old EU member countries - EU-12 group) in the period 2000-2009 using SVAR (structural vector autoregression) approach on each country individual data as well as panel data.. As sources of the exchange rates movements we consider three common exogenous structural shocks (also known as primitive shocks). In order to meet this objective we decompose the variability of the nominal effective exchange rates (NEER) and real effective exchange rates (REER) in these countries to permanent and temporary shocks (we assume three types of shocks - nominal[1] (liquidity)

[1] Nominal shocks are usually associated with the changes in relative money supply, liquidity preference, velocity shifts, varying risk premium, effects of financial liberalization and speculative currency attacks. Higher exposure of the real output to

shocks, demand[2] shocks and supply[3] shocks). Impulse-response functions are also computed in order to estimate the behaviour of NEER and REER after structural one standard deviation innovations. The relevant outcomes of the analysis we compare with the results of the tests for the whole euro area (represented here by old EU member countries - EU-12 group). This approach helps us to understand the common as well as differing features of NEER and REER determination in the European transition economies and old EU member countries.

## 3. Econometric model

Vulnerability of the exchange rates to the exogenous shocks came to the centre of an academic discussion shortly after a break-down of a Bretton Woods system of fixed exchange rates at the beginning of the 1970s. Uncertainty on the foreign exchange markets together with higher volatility of exchange rates increased a sensitivity of domestic economies to the foreign partners' economic development as well as to the world leading economies' exchange rate movements.

Main contribution to the analysis of structural exogenous shocks is addresses to Byoumi and Eichegreen (1993) who pioneered an identification scheme of underlying supply and demand shocks using technique introduced by Blanchard and Quah (1989). Their model considered two types of structural shocks (supply shocks and demand shocks) hitting an economy. So called primitive shocks were identified using long-run restrictions based on long-run neutrality of the real output to demand shocks, while it is suggested the supply shocks have permanent influence on the real output development (Fidrmuc - Korhonen, 2001).

The methodology we use in our analysis to recover nominal (liquidity), demand and supply shocks is based upon a SVAR model introduced by Clarida and Gali (1994), which implements a long-run identifying restrictions to the unrestricted VAR models pioneered by Blanchard and Quah (1989).

Unrestricted form of the model is represented by the following infinite moving average representation:

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \ldots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} = \sum_{i=0}^{\infty} A_i L^i \varepsilon_t \tag{1}$$

where $X_t$ is a vector of the endogenous macroeconomic variables, $A(L)$ is a polynomial variance-covariance matrix (represents impulse-response functions of the shocks to the elements of $X$) of lag-length $l$, $L$ is lag operator and $\varepsilon$ is a vector of identically normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances (vector of reduced form shocks in elements of $X$). The vector $X_t$ of the endogenous variables of the model consists of the following three elements: real exchange rate ($er_r$), nominal exchange rate ($er_n$) and real output ($y_r$).

In our tri-variate model we assume three exogenous shocks that determine endogenous variables - nominal shock ($\varepsilon_n$), demand shock ($\varepsilon_d$) and supply shock ($\varepsilon_s$). Our model then becomes

$$\begin{bmatrix} \Delta er_{rt} \\ \Delta er_{nt} \\ \Delta y_{rt} \end{bmatrix} = \sum_{i=0}^{\infty} \begin{bmatrix} a_{11i} & a_{12i} & a_{13i} \\ a_{21i} & a_{22i} & a_{23i} \\ a_{31i} & a_{32i} & a_{33i} \end{bmatrix} \begin{bmatrix} \varepsilon_{nt} \\ \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix} \tag{2}$$

The framework of the model implies that only supply shocks have a permanent effect on all endogenous variables. Demand shocks have permanent effect on the real and nominal exchange rate

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the nominal shock would indicate its higher sensitivity to the unexpected effects of money demand disturbances, money supply disturbances or both, etc.

[2] Demand shocks are usually associated with sudden changes in exports, government expenditures, etc.

[3] Supply shocks are usually associated productivity and labour market shocks, sudden changes in the input prices, etc.

while its impact on the real output is only temporary. Nominal shocks have permanent effect only on the nominal exchange rate while its impact on the real exchange rate and the real output is considered to be temporary. Identification of temporary impacts of selected exogenous shocks on the endogenous variables is represented in the model by the following long-run identifying restrictions

$$\sum_{i=0}^{\infty} a_{11i} = 0, \sum_{i=0}^{\infty} a_{31i} = 0, \sum_{i=0}^{\infty} a_{32i} = 0 \tag{3}$$

The model defined by equations (2) and (3) we estimate using a vector autoregression. Each element of $X_t$ can be regressed on lagged values of all elements of $X$. Using $B$ to represent these estimated coefficients, the estimated equation becomes

$$\begin{aligned} X_t &= B_1 x_{t-1} + B_2 x_{t-2} + \ldots B_n x_{t-n} + e_t = \sum_{i=1}^{n} B_i L^i X_t + e_t = B(L) X_t + e_t \\ &= \left(I - B(L)\right)^{-1} e_t \\ &= \left(I + B(L) + B(L)^2 + \ldots\right) e_t \\ &= e_t + D_1 e_{t-1} + D_2 e_{t-2} + D_3 e_{t-3} + \ldots \end{aligned} \tag{4}$$

where $e_t$ represents the residuals from the equations in the vector autoregression.

In order to convert equation (4) into the model defined by the equations (2) and (3), the residuals from the vector autoregression, $e_t$, must be transformed into nominal, demand and supply shocks, $\varepsilon_t$. Imposing $e_t = C\varepsilon_t$, it is clear, that nine restrictions are necessary to define nine elements of the matrix $C$. Three of these restrictions are simple normalizations, which define the variance of the shocks $\varepsilon_{nt}$, $\varepsilon_{dt}$ and $\varepsilon_{st}$ (it follows the assumption, that each of the disturbances has a unit variance, $var(\varepsilon) = I$). Another three restrictions comes from an assumption that identified shocks are orthogonal. Normalization together with an assumption of the orthogonality implies $C'C = \Sigma$, where $\Sigma$ is the variance covariance matrix of $e_n$, $e_d$ and $e_s$. The final three restrictions, which allow the matrix $C$ to be uniquely defined, reflect the long-run identifying restrictions mentioned in the equation (3). In terms of our vector autoregression model it implies

$$\sum_{i=0}^{\infty} \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \\ c_{31} & c_{32} & c_{33} \end{bmatrix} = \begin{bmatrix} 0 & . & . \\ . & . & . \\ 0 & 0 & . \end{bmatrix} \tag{5}$$

Final three long-run restrictions allows the matrix $C$ to be uniquely defined and the nominal, demand and supply shocks to be correctly identified - recovered from the residuals of the estimated VAR model. The system is now just-identified and can be estimated using structural vector autoregression, so that we can compute variance decomposition that represents the contribution of each shock to the variability in each endogenous variable (we do this for the real output only) and impulse-response functions that represent the short-run dynamics of each endogenous variable (we do this for the real output only) in response to all identified structural shocks.

If the exogenous structural shocks are correctly identified, we might expect the following results:

- In the short-run a positive relative nominal shocks leads NEER and REER depreciation. In the long run, there should be no effect on the REER development.

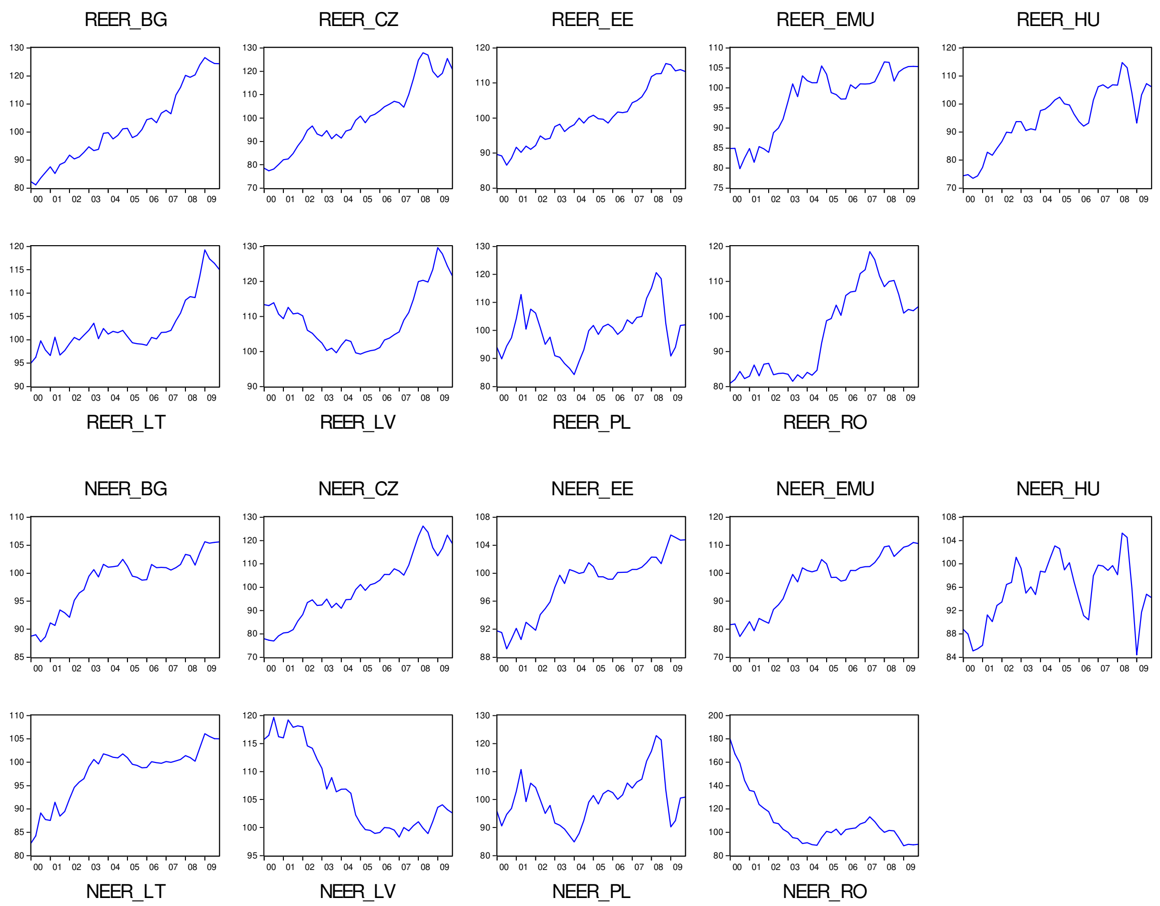
- In the short-run NEER and REER should appreciate after a positive relative demand shock. If the shock is permanent, REER should appreciate after a positive demand shock in the long-run.
- The effect of a positive relative supply to REER and NEER development should be ambiguous in the short-run, while in the long-run we expect an ambiguous effect only on REER.

## 2. Data and results

The methodology we use in our analysis to recover nominal (liquidity), demand and supply shocks is based upon a SVAR model introduced by Clarida and Gali (1994), which implements a long-run identifying restrictions to the unrestricted VAR models pioneered by Blanchard and Quah (1989).

In order to estimate our model consisting of three endogenous variables for the European transition economies (Bulgaria, the Czech republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania) we use the quarterly data ranging from 2000Q1 to 2009Q4 (40 observations) for the nominal effective exchange rates[4], real effective exchange rates[5] and real GDP. Time series for the quarterly real GDP are seasonally adjusted.

Figure 1 shows the development of the endogenous variables for the European transition economies and the euro area.




[4] Nominal effective exchange rates are calculated as geometric weighted averages of bilateral exchange rates.
[5] Real effective exchange rates are the same weighted averages of bilateral exchange rates adjusted by relative consumer prices.

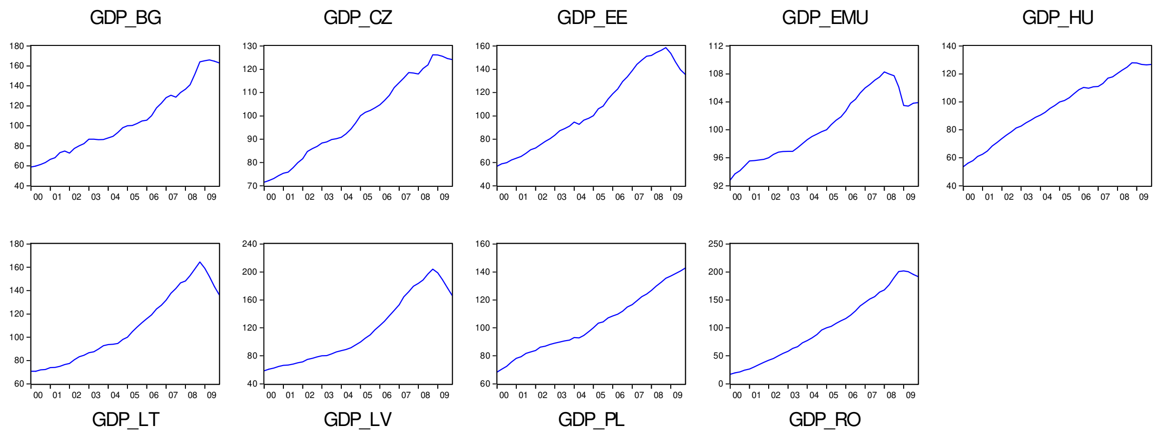


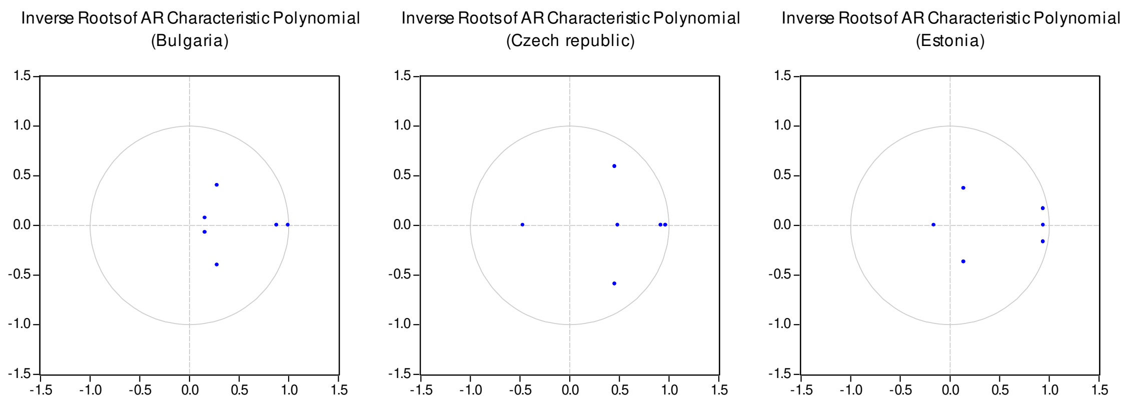

**Figure 1**. Variables

**Source:** BIS, OECD

Before we estimate the model it is necessary to test the time series for stationarity and cointegration. The augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests were computed to test the endogenous variables for the existence of unit roots. Both ADF and PP tests indicate that all variables are non-stationary on the values so that the null hypothesis of a unit root cannot be rejected for any of the series. Testing variables on the first differences indicates the time series are stationary so that we conclude that the variables are I(1).

Because all endogenous variables have a unit root on the values it is necessary to the test the time series for cointegration using the Johansen cointegration test. The test for the cointegration was computed using two lags as recommended by the AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion). The results of the Johansen cointegration tests confirmed the results of the unit root tests. Both trace statistics and maximum eigenvalue statistics (both at 0.05 level) indicate that there is no cointegration among the endogenous variables of the model. The results of unit root and cointegration tests are not reported here to save space. Like any other results, they are available upon request from the author.

To test the stability of the VAR model we also applied a number of diagnostic tests. We found no evidence of serial correlation, heteroskedasticity and autoregressive conditional heteroskedasticity effect in the disturbances. The model also passes the Jarque-Bera normality test, so that errors seem to be normally distributed. The VAR models seem to be stable also because the inverted roots of the model for each country lie inside the unit circle (figure 2).



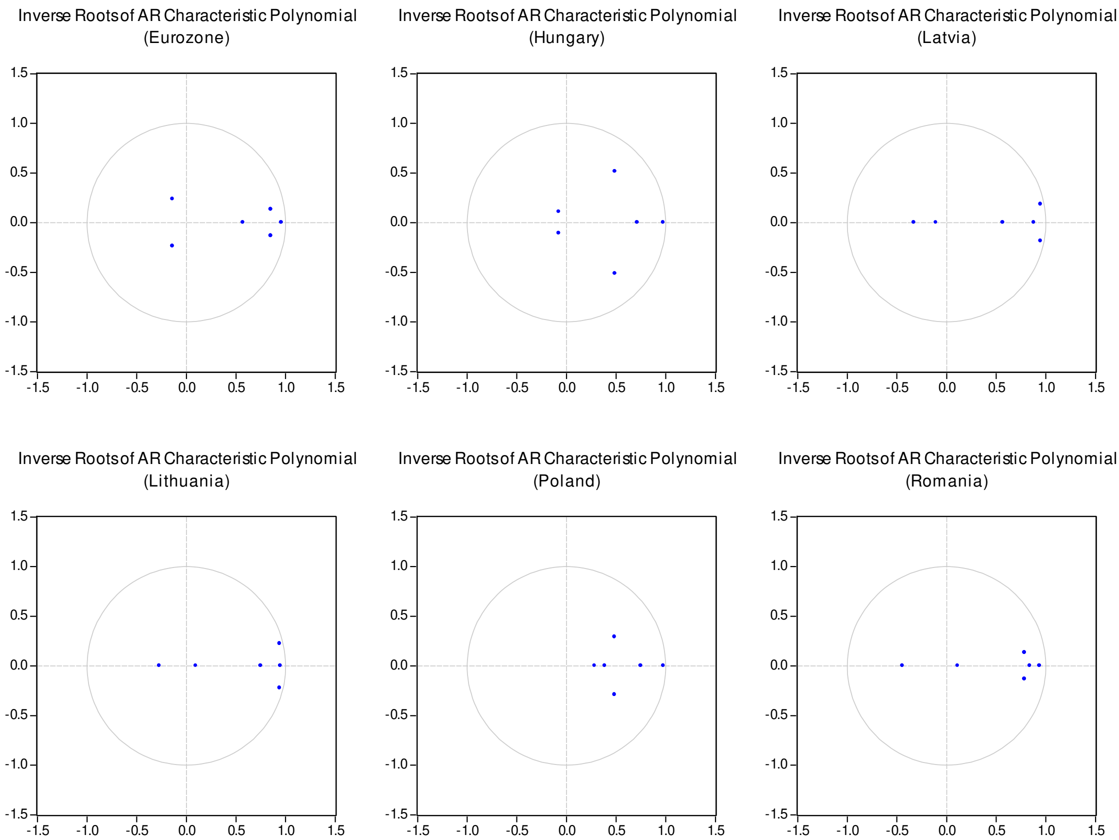



**Figure 2.** VAR stability condition check

**Source:** Author's calculations.

Following the results of the stationarity and cointegration tests we estimate the model using the variables in the first differences so that we can calculate variance decomposition and impulse-response functions of endogenous variables (NEER and REER) of the model (responses of endogenous variables to one standard deviation government expenditures and tax revenues shocks) for each country from the selected group. In figures 3 and 4 we summarize the variance decomposition (contributions of each structural shock to NEER and REER conditional variance) and impulse-response functions (responses of NEER and REER to one standard deviation structural shocks) of NEER and REER for the selected European transition economies and the euro area. In figures 5 and 6 we summarize the responses of NEER and REER to the unexpected structural shocks. In figures 7 and 8 we summarize the results of variance decomposition and impulse-response function using panel data for the whole group of the European transition economies.

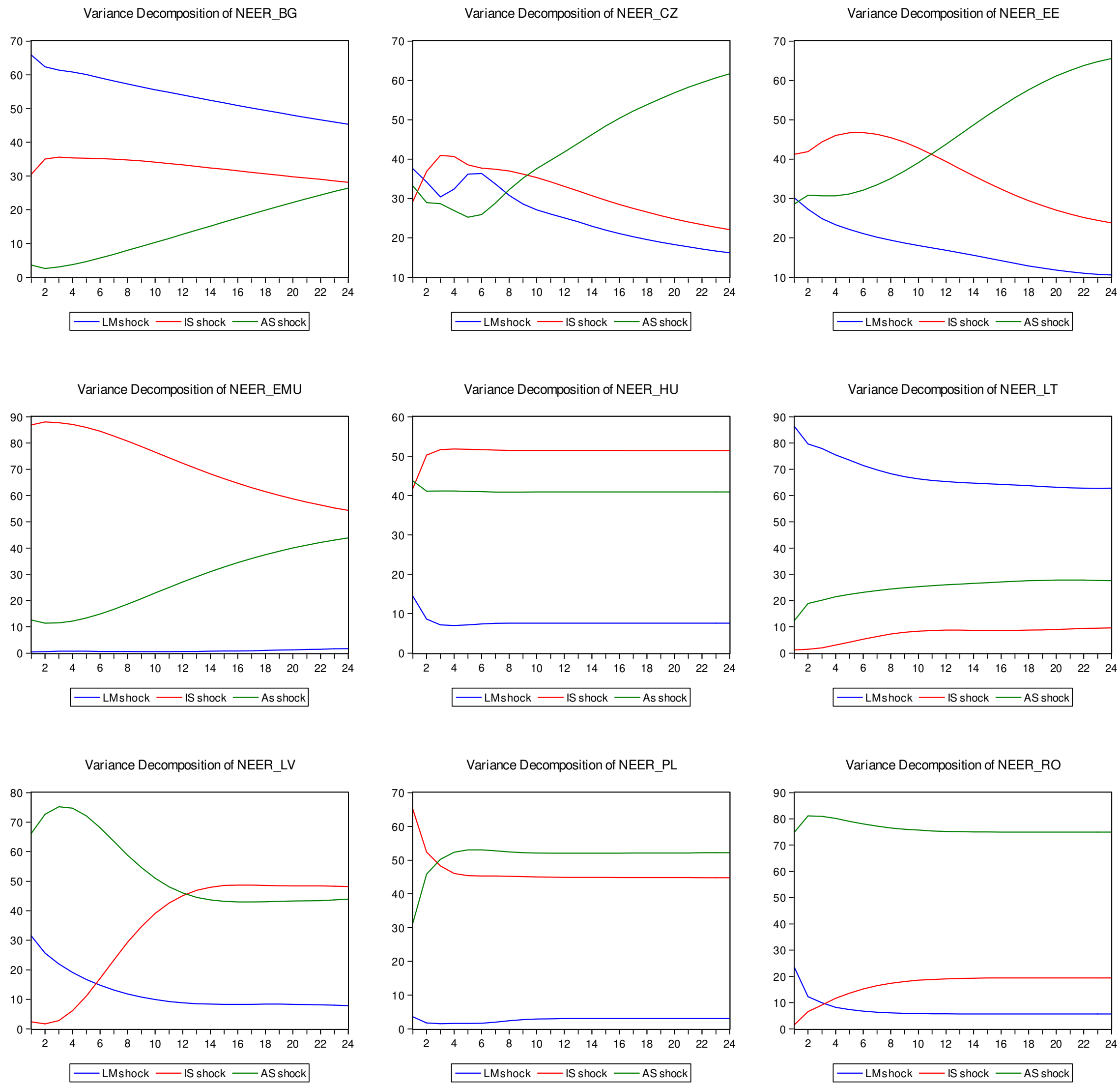



**Figure 3.** Variance decomposition (NEER)

**Source:** Author's calculations.

The figure 3 reflects the variance decomposition of NEER in the selected group of the European transition economies and euro area that reports the contribution of each structural shock to the conditional variance of NEER at the various forecast horizons (up to 24 quarters). The variance decomposition of NEER reflects a negligible role of the nominal (liquidity) shock in the variability of NEER only in Poland and euro area during whole forecast period. Relatively stable, thought rather low, seems to be contribution of nominal shock in the NEER variability in Hungary. In the remaining countries the overall effect of the nominal shock on NEER variability fades out with increasing forecast period. While in Bulgaria and Lithuania the contribution of nominal shock in NEER variability seems to be the highest among all countries from the group, in Romania it plays only negligible role.

Demand shock seems to have rather similar contribution in the NEER variability in Bulgaria, the Czech republic and Estonia. Its relatively stable influence and persistency was observed in Hungary, Poland and partially in euro area. The role of the demand shock in the NEER variability increased relatively sharp Latvia. In Lithuania and Romania the demand shock determined the NEER development with only minor relevancy.

Supply shock significantly contributed to the NEER variability in Hungary, Latvia, Poland and Romania. Its importance steadily increased in the later stages of the forecast horizon in the Czech republic, Estonia and partially in Bulgaria and euro area.

In general it seems the NEER variability in the selected group of countries differs significantly in each particular case. All exogenous shocks determined NEER variability in each country with rather different intensity and durability. We didn't experience any significant similarity in NEER determination between any of the selected group of countries and euro area.

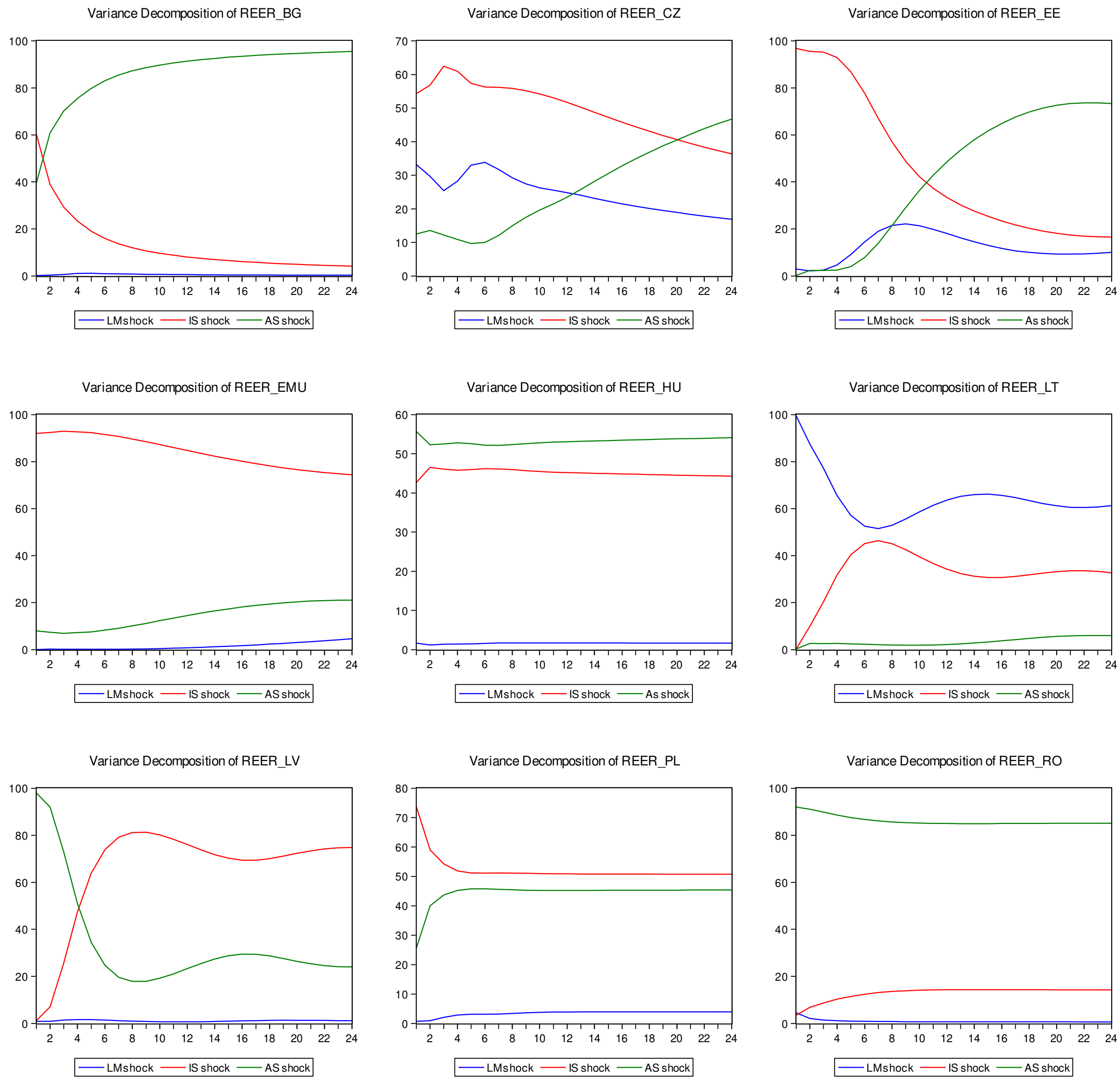



**Figure 4.** Variance decomposition (REER)

**Source:** Author's calculations.

The figure 4 describes the variance decomposition of REER in the selected group of European transition economies and euro area at various forecast horizons (up to 24 quarters). The results reflect rather interesting outcomes especially when comparing the contribution of structural shocks in NEER and REER variability. NEER and REER responded to all three exogenous shocks quite similar in the Czech republic, Hungary, Latvia, Poland, Romania as well as euro area. In all these countries we experienced approximately the same direction in which the shocks determined NEER and REER variability, though we observed certain differences in the intensity and durability of the shocks in the forecast period. On the other hand in Bulgaria and Lithuania the contribution of exogenous shocks in

NEER and REER variability seems to be quite different. We suggest it is especially due to the trend of continuous appreciation of REER during last few years in both countries while NEER experienced the period of relative stability.

Considering the long-run restrictions imposed on the unrestricted VAR model, the long-run neutrality of the nominal shock in the REER variability was not confirmed in Lithuania, while in the Czech republic and Estonia it took much more time (than forecasted 24 quarters horizon) to prove this expectation.

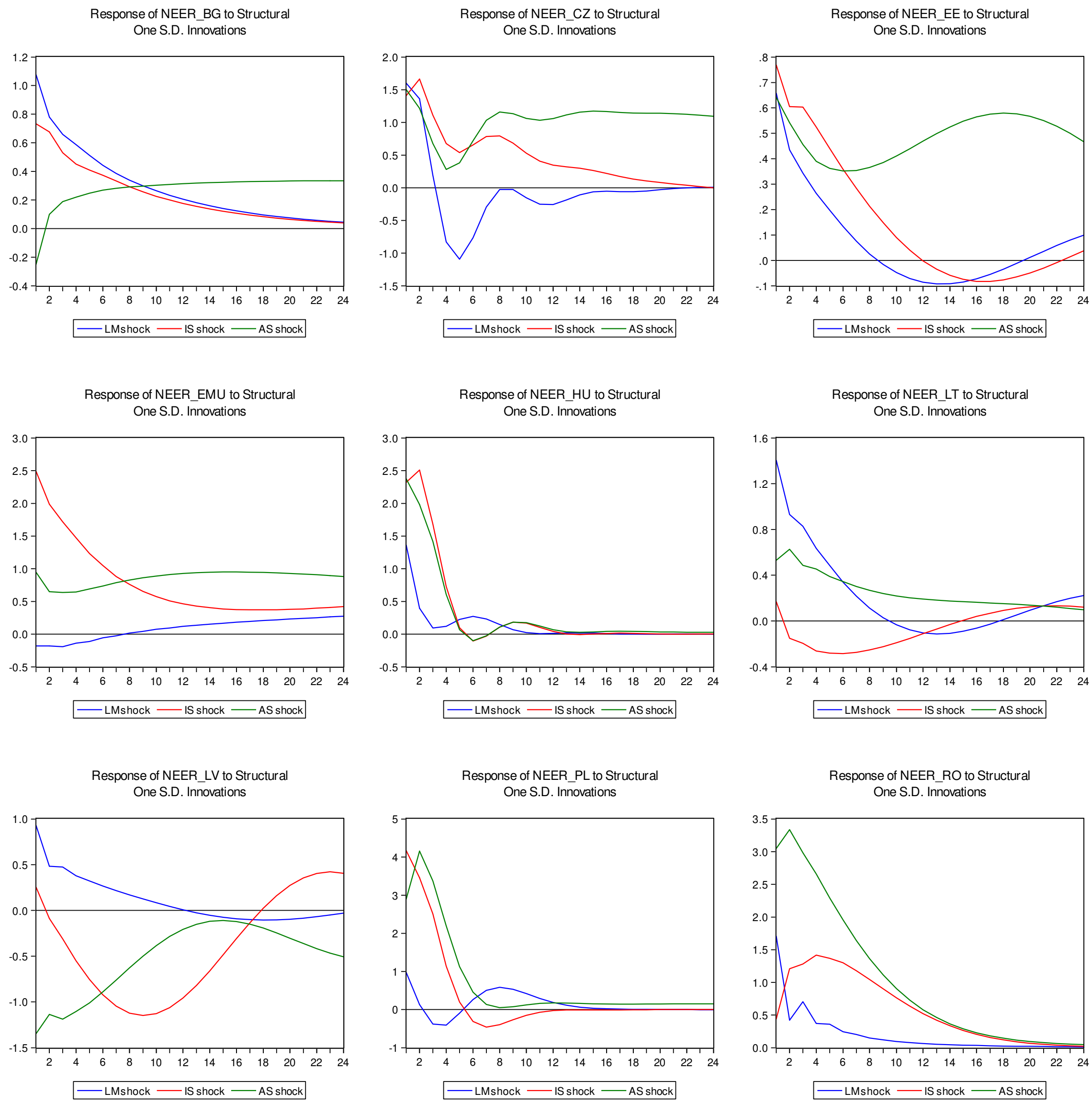



**Figure 5.** Response of NEER to exogenous shocks

**Source:** Author's calculations.

The figure 5 reflects the impulse-response functions that show the responses of NEER to the structural one standard deviation nominal, demand and supply shocks. After positive one standard deviation nominal (liquidity) shock NEER appreciated markedly in Bulgaria, Estonia, Hungary, Lithuania, Latvia and Romania. In the Czech republic and Poland the positive one standard deviation demand shock didn't seem to have a clear impact on the NEER development and was associated with an increased instability of NEER especially in the short period. Relatively surprising seems to be the almost neutral response of NEER in the euro area. In all countries nominal shock seems to have only temporary effect on the NEER development. The demand shock forced NEER appreciation in the most of the countries while it fade out with a different intensity. We suggest the positive demand shock associated with flexible response of the domestic supply can stimulate an economic growth followed by NEER appreciation. On the other hand in Latvia and Lithuania the positive demand shock was followed by the NEER depreciation. It can be expressed as a result of a possible import pressures followed by an increased demand resulting from demand shock that would weaken NEER. It seems the supply shock had permanent effect on NEER in Bulgaria, the Czech republic and euro area. A negative impact of supply shock on the NEER development was observed only in Latvia.

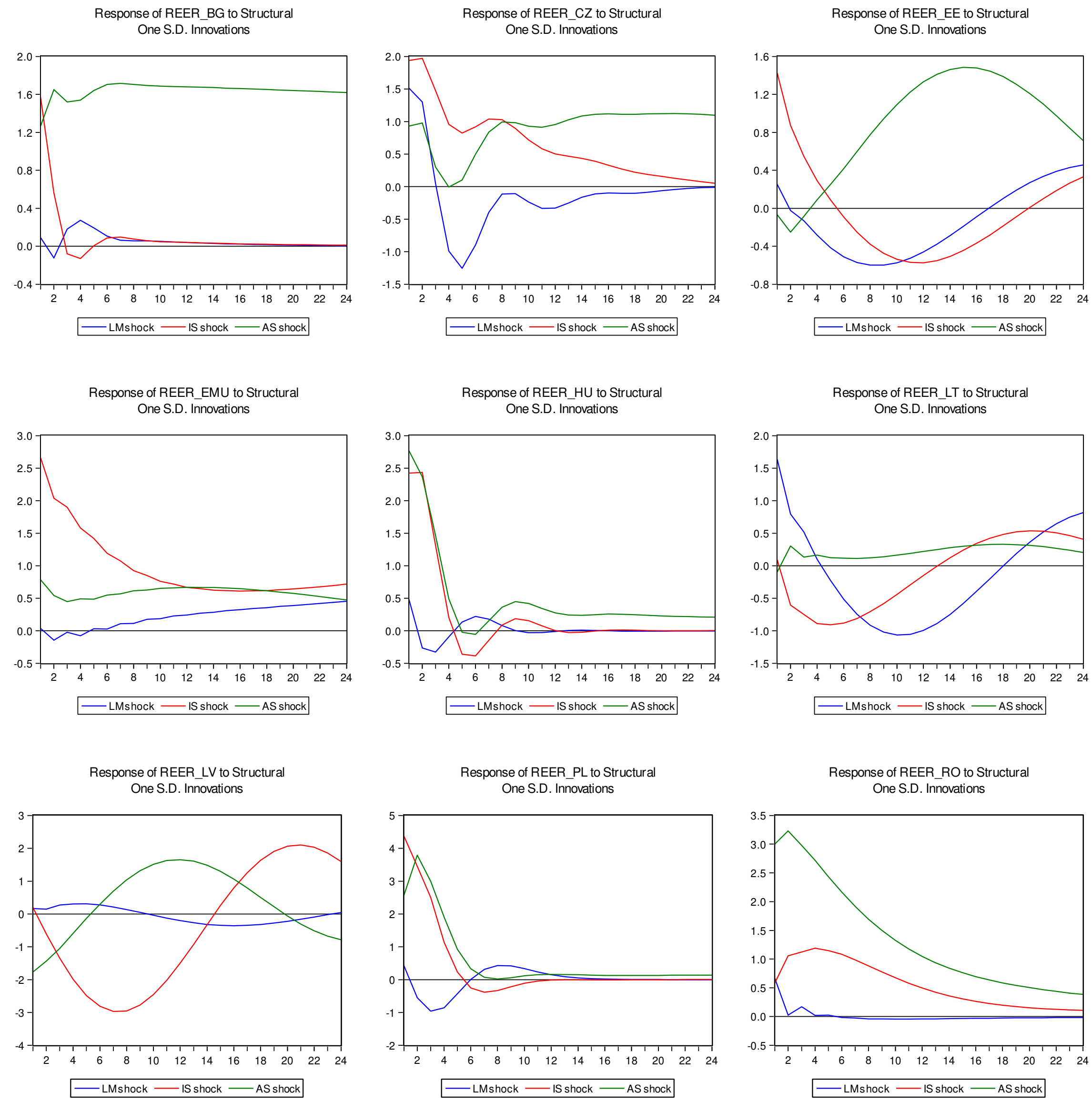



**Figure 6.** Response of REER to exogenous shocks

**Source:** Author's calculations.

The figure 6 demonstrates the impulse-response functions of REER to the one standard deviation nominal, demand and supply shocks. In contrast to variance decomposition of NEER and REER we have experienced quite high degree of similarity in responses of NEER and REER to the structural shocks. Certain differences can be found in the intensity and durability of shocks.

## Panel data for the European transition economies

In order to analyze the sources of exchange rates fluctuations in the selected group of the European transition economies more comprehensively we have also estimated SVAR model in order to estimate variance decomposition and impulse-response functions of NEER and REER in the selected countries using panel data. Before we estimated model we performed panel unit root test as well as panel cointegration test. Like any other results, they are available upon request from the author.

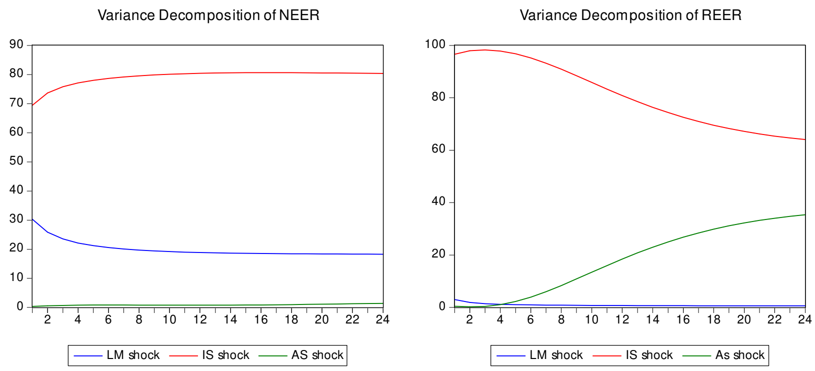



**Figure 7.** Variance decomposition of NEER and REER

**Source:** Author's calculations.

The figure 7 reflects the variance decomposition of NEER for the whole group of the European transition economies. The variance decomposition of NEER reflects a negligible role of the supply shock in the variability of NEER. This result seems to be quite surprising especially in comparison with the variance decomposition of NEER using data for each individual country. The results also reflects high importance of demand shock and relatively low contribution of the nominal shock in the determining the NEER development. Variance decomposition of REER for the whole group of the European transition economies reflects quite different results. Nominal shock doesn't seem to have any impact on the REER development. Quite interesting is a steadily raise of the supply shock contribution in the REER variance that seems to be at the expense of a continuously diminishing role the demand shock.

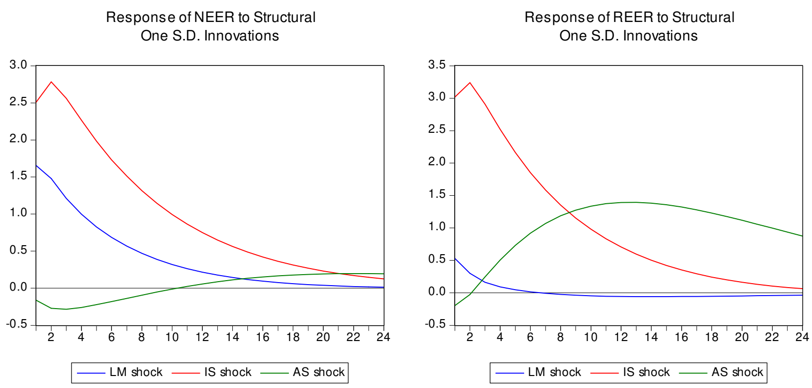



**Figure 8.** Response of NEER and REER to exogenous shocks

**Source:** Author's calculations.

The figure 8 reflects the impulse-response functions of NEER to the structural one standard deviation exogenous shocks for the whole group of the European transition economies. In general the response of NEER and REER to the nominal and demand shocks for the whole group seems to be quite similar to our findings from the analysis performed for each individual country. Both NEER and REER appreciated after one standard deviation positive nominal and demand shocks, thought the positive response of REER to the nominal shock seems to be much weaker and shorter. Quite different results we observed for the responses of NEER and REER to the positive supply shock. While NEER in case of each individual country responded quite different (NEER mostly appreciated) to the supply shock, for the whole group NEER remained almost stable after positive supply shock. On the other hand REER steadily appreciated after one standard deviation supply shock, thought in the long run its effect slowly fades out.

## 4. Conclusion

In the paper we have analyze the sources of exchange rate movements in the European transition economies (Bulgaria, the Czech republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania) and euro area (represented here by old EU member countries - EU-12 group) in the period 2000-2009 using SVAR (structural vector autoregression) approach on each country individual data as well as panel data in order to estimate the sources of the NEER and REER variability.

Variance decomposition allowed us to estimate the contributions of the primitive exogenous shocks to the NEER and REER conditional variance. Impulse-response functions expressed the responses of NEER and REER to one standard deviation nominal, demand and supply shocks. Comparing the result for each of the country from the group of the European transition economies and the euro area (for our purposes it represented group of EU-12 member countries) we may summarize our findings: (1) NEER and REER conditional variance in the selected countries seems to be determined quite differing way so that the exchange rates development cannot be clearly explained by the influence of common or similar determinants. It is also difficult to find any significant similarities in the sources of NEER and REER fluctuations between the countries from the group of the European transition economies and euro area. (2) In most of the countries NEER and REER appreciated after positive nominal, demand and supply shock, though we found some differences in the magnitude and durability of the exchange rates response. NEER and REER in the European transition economies responded to the nominal shock more markedly than NEER and REER of euro area. (3) Panel data analysis for the European transition economies revealed rather different results for the variance decomposition and the impulse-response function of NEER and REER in comparison with the analysis for the each individual country. We suggest it is especially due to existence of many country specific features that determines exchange rates development quite different way.

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