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Testing 'the trilemma' in post-transitional Europe: a new empirical measure of capital mobility

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Abstract

This paper develops a new empirical measure of capital mobility. It tests the hypothesis that the degree of capital mobility can be estimated by measuring the reaction intensity of capital flows to shocks in interest rates, on a sample of eight European post-transitional economies. This hypothesis can be derived from the Mundell-Fleming open economy model, implications of which are essentially based on the assumption of a close link between the degree of capital mobility in a country and the reaction of its capital flows to changes in domestic and external interest rates. Precisely because of this interrelationship, policy holders, in theory, face the policy trilemma or the 'impossible trinity', i.e. the inability to achieve three following objectives simultaneously – a stable exchange rate, financial openness, and an independent monetary policy. Using impulse response and historical decomposition analysis in a VAR framework, the results show a significant increase in the explanatory power of interest rates for the movement of capital flows shortly before and after the accession of post-transitional economies to the European Union. On the other hand, the recent financial crisis made capital flows less sensitive to interest rates due to increased risk aversion on international capital markets. Results suggest that the degree of capital mobility, i.e. the level of financial integration with EU-15, is highest in Bulgaria, Latvia and Lithuania, and least pronounced in Poland and Croatia. Results are verified by a number of robustness checks, with three separate alternative measures of capital mobility confirming the results obtained from the econometric model.

Key words

capital flows; capital mobility; the trilemma; impossible trinity; interest rate shocks; VAR model; historical decomposition

JEL classification

F21, F32, F36

Introduction

Measuring of the degree of international capital mobility has long been a subject of scientific research and debate. In the existing empirical literature capital mobility has been measured in many ways, but two basic approaches can be distinguished. The first approach is based on the interdependence of domestic savings and investment, which was introduced by Feldstein and Horioka (1980). They argued that if the capital mobility is high, domestic savings should seek highest returns, regardless of the domestic demand for investment. Likewise, domestic demand for investment will be satisfied on international financial markets, regardless of domestic savings levels. This should imply, they argued, that the correlation between domestic investments and savings amongst open OECD economies should be low. However, Feldstein and Horioka showed that the correlation was 'puzzlingly' high, implying low capital mobility. Their model was used by many authors in the following years, e.g. Bayoumi and Rose (1993), Frankel (1993), Bayoumi (1997), Van Wincoop (2000), Blanchard and Giavazzi (2002), Alfaro *et al.* (2005), etc.

The second approach is based on the testing of the well-known interest rate parity hypothesis between countries (see Haque and Montiel 1991, Frankel 1991, Montiel 1994, Schmitt-Grohé and Uribe 2008, etc.). Many alternative measures of capital mobility have also been used in the literature, e.g. the volume of gross capital flows (Calvo *et al.* 1993, Lane and Milesi-Ferretti 2007), the degree of monetary policy autonomy (Cumby and Obstfeld 1984, Dowla and Chowdhury 1991), testing the Euler equations of intertemporal consumption (Obstfeld 1986, 1989, Lemmen and Eijffinger 1995) and various administrative measures (Quinn 2003, Edison and Warnock 2003, Mody and Murshid 2005).

This paper tests the hypothesis that the degree of capital mobility in European post-transitional economies (EU new member states) can be estimated by measuring the intensity of reaction of capital flows to shocks in domestic and eurozone interest rates. Theoretical justification for this approach can be derived from the Mundell-Fleming open economy model which is based on the essential assumption that foreign investors, in terms of perfect capital mobility, react strongly to changes in domestic interest rates relative to foreign interest rates. If the domestic interest rate rises above the foreign interest rate, foreign investors will buy domestic currency bonds which will result in the appreciation of the domestic currency. If a country has a fixed exchange rate, the central bank must defend the exchange rate on a certain level and adjust its monetary policy accordingly in order to return the interest rate to the foreign interest rate level, thereby annulling the relative attractiveness of the domestic bond. This implies that the policy holders cannot achieve three following objectives simultaneously – a stable exchange rate, financial openness, and an independent monetary policy – thus facing the monetary policy trilemma, i.e. the impossible trinity.

Due to the fact that all EU member states have had to give up all capital controls, i.e. must ensure the free flow of capital, one of the sub-hypotheses of the paper is that the reaction of capital flows in these countries to changes in domestic and foreign interest rates should be more intensive after the accession than in the period prior to the EU accession. This means that it should be possible to estimate the degree of capital mobility in EU NMS by measuring the intensity of the response of capital flows to shocks in domestic and eurozone interest rates. The other sub-hypothesis is that the explanatory power of interest rates has decreased during the recent financial crisis due to factors other than interest rates becoming more important determinants of capital flows.

The significance of interest rates as one of the key determinants of international capital flows has been repeatedly empirically confirmed (see Chuhan *et al.* 1993, Gavin *et al.* 1995, Fernández-Arias 1996, Calvo and Reinhart 1996, Frankel and Okongwu 1996, Eichengreen and Mody 1998, Gibson and Tsakalotos 2004, BIS 2009, Hadiwibowo and Komatsu 2011, etc.). However, to the best of our knowledge, approach employed in this paper has not yet been implemented in the empirical literature as a measure of capital mobility, nor has the temporal dynamics of the impact of interest rates changes on capital flows been analysed. This research, thus, represents a contribution to economic science in the field of empirical measurements of the degree of international capital mobility. To verify the

robustness of results obtained from the econometric model, in addition to two conventional measures of capital mobility (Feldstein-Horioka regressions and tests of uncovered interest rate parity), an alternative way of measurement of capital mobility is introduced, using the so-called trilemma indices.

The remainder of the paper is structured as follows. The second section presents the data and the model for empirical analysis, while the third carries out the methodological details. Results of the VAR model are presented in section four, while the fifth section deals with robustness checks using alternative measures of capital mobility. The sixth section concludes the paper.

Data and model

Empirical analysis will be carried out on a sample of eight European post-transitional (EU NMS) economies. Although the initial idea was to analyse all NMS except Cyprus and Malta, the sample had to be reduced solely to countries outside the eurozone – Bulgaria, Czech Republic, Croatia, Latvia, Lithuania, Hungary, Poland and Romania. The reason is the fact that Slovenia, Slovakia and Estonia have lost their monetary sovereignty by joining the monetary union. By entering the eurozone, these countries ceased to manage their own interest rates, which have since then been under the direct control of the European Central Bank. The analysis is carried out on quarterly data covering the period from 1997:Q1 to 2011:Q4. Due to the unavailability of data, in case of Poland this period starts from 2000:Q1. Once the results from the econometric model are obtained, they will be compared with the results of other measures of capital mobility as a robustness check.

Based on theoretical assumptions of the Mundell-Fleming model (for details see e.g. Schmitt-Grohé and Uribe 2008, Acocella 2009), and previous empirical research (see Frankel and Okongwu 1996, Hadiwibowo and Komatsu 2011), an empirical model is derived such that total net capital flows (CAP_t) are a function of a foreign interest rate, domestic interest rate and the exchange rate:

$$CAP_t = f(I\_EU_t, I_t, E_t) \qquad (1)$$

where I_EU_t represents the benchmark eurozone interest rate, I_t represents the domestic interest rate, E_t represent the exchange rate of the domestic currency against the euro. Economic theory indicates the following signs of partial derivatives: $\frac{\partial CAP}{\partial I\_EU} < 0$, $\frac{\partial CAP}{\partial I} > 0$, $\frac{\partial CAP}{\partial E} < 0$.

Data on capital flows are obtained from the IMF's International Financial Statistics (IFS) database. Total net capital flows are calculated as a sum of net foreign direct investment, portfolio and other investment. Capital flows are presented in the form of a moving annual cumulative, expressed as a percentage of GDP. This decreases the volatility of capital flows and offsets the seasonality in the GDP and capital flows time series.

The primary sources of data on interest rates were the IFS and Eurostat databases. Domestic interest rates are represented by domestic short-term money market rates, while the foreign interest rate is given by the 3-month EURIBOR. Finally, data on exchange rates are taken from Eurostat and are presented in the form of an index, with 2005 as the base year. Time series have been seasonally adjusted using the *X11* procedure in the *WinRATS 8* software. In order to ensure the stationarity of variables, deterministic components (constant and trend) have been removed from all time series, in accordance with the procedure used by Blanchard and Quah (1989). Figure 1 displays the time series of variables used in the empirical analysis.

[FIGURE 1 ABOUT HERE]

The data for analysed countries support the hypothesis that the degree of capital mobility can be estimated by the response intensity of capital flows to changes in domestic and eurozone interest rates. In fact, capital flows to European post-transitional economies have been most intensive during mid-2000s until the outbreak of the global crisis, which is precisely the time when the differentials between

domestic and eurozone interest rates were at their lowest levels across all analysed countries (Figure 1). An increase in the level of financial integration between EU-15 countries and NMS has been confirmed by previous empirical studies (Lane and Milesi-Ferretti 2006, Chinn and Ito 2006, 2008, Ötker-Robe *et al.* 2007, etc.), suggesting increased mobility of capital in these countries, meaning that it took less additional return to attract larger amounts of foreign capital.

Stationarity of time series has been tested using Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests. Table 1 displays the results of the ADF test, while the results of the KPSS test are not shown due to limited space, but are available upon request.

[TABLE 1 ABOUT HERE]

Results of both tests showed that all time series are in a stationary form (some after taking first differences) with usual levels of significance, and as such can be included in the vector autoregressive (VAR) model.

Methodology

Methodological framework for empirical research is based on a four variable VAR model which facilitates the modelling of the impact of interest rate and exchange rate shocks on capital flows and modelling the simultaneous interrelationships between variables, which are treated endogenously. VAR model in a reduced form can be written as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t \qquad (2)$$

where y_t is a vector of endogenous variables, $A_i (i = 1, \dots, p)$ are $(K \times K)$ parameter matrices, error process $e_t = (e_{1t}, \dots, e_{Kt})$ is a *K*-dimensional zero mean white noise process with covariance matrix $E(e_t e_t') = \sum_e$, that is, $e_t \sim (0, \sum_e)$, and p is a number of lags in the model. The basic specification of the model is represented by the following vector of endogenous variables, with the corresponding Cholesky ordering of variables:

$$y_t = (I\_EU_t, I_t, E_t, CAP_t) \qquad (3)$$

The ordering of variables in vector y_t is a result of Granger causality tests. However, results are robust even under alternative orderings of variables. Granger causality test results are available upon request.

Optimal number of lags in VARs has been determined by the minimization of Akaike and Hannan-Quinn information criteria. A dummy variable *CRISIS* has been included to control for the period of sudden stop of capital flows during the global financial crisis (equals 1 in the period 2008:Q4–2011:Q4, 0 otherwise). Residuals from estimated models have been tested for autocorrelation using the multivariate serial correlation test (Hosking Q-statistics). The results, available upon request, indicate that the null hypothesis of no serial correlation cannot be rejected.

Results of the econometric analysis will be presented using two components of the VAR model – impulse response functions and the historical decomposition.

Historical decomposition provides insight into the contributions of individual shocks to the observed data series. The sum of contributions of all components (shocks) added to the base forecast results in the actual data series. If one or more of those components is omitted, we get an insight into what data would have been generated if some linear combinations of the residuals had been zero rather than what was actually observed (Doan 2010).

The first paper using the historical decomposition was the one by Burbidge and Harrison (1985). Historical decomposition reorganizes the moving average representation for a time series vector y_t such that the *j*th variable can be written as (Lütkepohl 2011):

$$y_{jt} = \sum_{i=0}^{\infty} (\psi_{j1,i} u_{1,t-i} + \cdots + \psi_{jK,i} u_{K,t-i}) \quad (4)$$

where $\psi_{jk,i}$ is the (*j*,*k*)th element of the structural moving average (MA) matrix Ψ_i, and u_t is a vector of transformed VAR residuals e_t such that $u_t = A^{-1} e_t$. That makes

$$y_{jt}^{(k)} = \sum_{i=0}^{\infty} \psi_{jk,i} u_{k,t-i} \quad (5)$$

the contribution of the *k*th structural shock to the *j*th variable in vector y_t. Due to the fact that the shocks are not available, it is necessary to estimate the shocks associated with the sample period and use an estimated historical decomposition. By successive substitution, the VAR process (5) can be written as

$$y_t = \sum_{i=0}^{t-1} \Phi_i e_{t-i} + A_1^{(t)} y_0 + \cdots + A_p^{(t)} y_{1-p} = \sum_{i=0}^{t-1} \Psi_i u_{t-i} + A_1^{(t)} y_0 + \cdots + A_p^{(t)} y_{1-p} \quad (6)$$

where Φ_i is an MA coefficient matrix from the reduced form VAR, and the $A_i^{(t)}$ are such that $\left[A_1^{(t)}, \ldots, A_p^{(t)}\right]$ consists of the first K rows of the $(pK \times pK)$ matrix A^t, where

$$\mathrm{A} = \begin{bmatrix} A_1 & \cdots & A_{p-1} & A_p \\ I_K & \cdots & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots \\ 0 & \cdots & I_K & 0 \end{bmatrix} \quad (7)$$

Finally, y_{jt} can be decomposed as (Lütkepohl 2011):

$$y_{jt}^{(k)} = \sum_{i=0}^{t-1} \psi_{jk,i} u_{k,t-i} + \alpha_{j1}^{(t)} y_0 + \cdots + \alpha_{jp}^{(t)} y_{1-p} \quad (8)$$

where $\alpha_{ji}^{(t)}$ is the *j*th row of $A_1^{(t)}$. The contribution of the *k*th structural shock to the *j*th component series of y_t is represented by $y_{jt}^{(k)}$. Since all unknown parameters need to be estimated, the estimated series $\hat{y}_{jt}^{(k)}$, $k = 1, \ldots, K$represent a historical decomposition of y_{jt}.

Confidence intervals in impulse response functions have been obtained using Monte Carlo bootstrapping method with Cholesky factorization. The same factorization was used for the historical decomposition.

Results

Impulse response functions of total net capital flows to shocks in interest rates and exchange rates are shown in Figure 2. A positive shock in eurozone interest rates has an expected negative impact on net capital flows in the Czech Republic, Hungary and, after four and six quarters, Romania and Latvia respectively. However, one should bear in mind that total capital flows are the sum of different forms of capital, which have different characteristics and may have different degrees of sensitivity and different direction of reaction to shocks in interest rates. By their characteristics and the motivation of investors, the most interest rate sensitive form of capital flows are portfolio investments. After the initial positive reaction, impulse response functions of this type of foreign investment, however, reveal

the expected negative connection between interest rates in the eurozone and capital flows in all post-transitional economies. The results for portfolio investments are not included due to the restricted space, but are available upon request.

[FIGURE 2 ABOUT HERE]

Economic theory suggests that a rise in domestic interest rates should result in higher net capital inflows, but Figure 2 reveals that the expected direction has an empirical confirmation in only five of eight analysed countries. The absence of a positive relationship in some countries could be the result of a negative correlation of capital flows with the risk factor, i.e. due to the stronger impact of risk aversion on investment decisions of foreign investors relative to the attractiveness of potentially higher returns on investment. This is supported by the fact that the biggest drop in capital flows to post-transitional countries has been recorded over the period of accelerating growth in interest rates after the collapse of Lehman Brothers in late 2008 (Figure 1). Such movements are characteristic for developing economies. Studies have shown that the negative relationship between domestic interest rates and capital flows does not typically occur in advanced economies, which have historically recorded considerably fewer financial crises (IMF 2011).

Another potential reason for the negative relationship between domestic interest rates and capital flows could be associated with the role of the government in attracting foreign capital. Foreign investment in domestic government bonds make up a significant proportion of total capital inflows in post-transitional countries, and Hadiwibowo and Komatsu (2011) point out that investments in government securities do not necessarily follow the usual and theoretically assumed patterns of interrelations between interest rates and capital flows.

Figure 2. reveals a negative relationship between the exchange rate (domestic currency depreciation) and net capital flows. This direction of the response is expected, given that the depreciation of the domestic currency reduces the real value of investments expressed in the currency of foreign investors.

In order to investigate the temporal dynamics of the impact of interest rates shocks on net capital flows to European post-transitional countries, the historical decomposition of capital flows was analysed. Capital flows component under the direct influence of eurozone interest rates is given by *IREU*, capital flows component under the direct influence of domestic interest rates by *IRDOM* and the component of capital flows under the summarized influence of both interest rates by *IRTOT*. Figure 3 displays the movement of components obtained by the historical decomposition, in relation to the movement of actual total net capital flows in each analysed country.

[FIGURE 3 ABOUT HERE]

In order to gain insight into the correlation between the extracted components of the historical decomposition with observed total capital flows, the static and dynamic correlation coefficients have been calculated. The analysis covers the whole period (1997:Q1–2011:Q4), but also the two sub-periods, covering the period before and after the country's entry into the European Union.[1] Dynamic correlations have been obtained by centred moving correlation coefficients covering the period of four years (16 observations).

Results show that the static correlation between *IREU* and actual total capital flows has increased in all post-transitional countries after their accession to the European Union, with the exception of Romania, where an increase in the correlation occurred during the 2004 wave of EU enlargement (Table 2). In most countries, there was a decline of correlation between the *IRDOM* component and observed total capital flows. Overall, the correlation of *IRTOT* (component of capital flows under the influence of both domestic and foreign interest rate) with actual capital flows has increased in all countries, except in Romania and the Czech Republic, where it has remained at about the same level.

[1] Since Croatia has not yet had entered the European Union during the analysed period, the starting point for the second sub-period has arbitrarily been set to those of the last two EU members – Romania and Bulgaria.

[TABLE 2 ABOUT HERE]

More precise information on the temporal dynamics of explanatory power of components from historical decomposition in determining the dynamics of total capital flows have been obtained by analysing dynamic correlation coefficients. Figure 4 confirms that the correlation between *IRTOT* and observed capital flows started to increase in all analysed countries shortly before and after joining the EU, noting that the rise in the correlation in Bulgaria started earlier – simultaneously with the countries which joined the EU in 2004. The period of high and rising explanatory power of interest rates continued in most countries until the onset of the financial crisis (2008:Q4), followed by a decline as a result of high levels of risk aversion.

[FIGURE 4 ABOUT HERE]

A comparative analysis of maximum values of dynamic correlation coefficients across countries shows that the correlation between component *IRTOT* and actual capital flows was highest in Bulgaria, Hungary, Latvia and Lithuania, and lowest in Poland (Figure 5), which indicates high degrees of capital mobility in the former group of countries, and lowest in the latter. Similar conclusions hold if the average values of dynamic correlation coefficients in the most intense period of capital flows (2004–2007) are examined, but with minor changes in the order of countries.

[FIGURE 5 ABOUT HERE]

The degree of capital mobility amongst post-transitional economies could also be estimated by comparing the intensity of capital flows reaction to interest rate shocks via impulse response functions (shown in Figure 2.). Figure 6 displays the levels of maximum reactions of capital flows to shocks in domestic and eurozone interest rates. It is evident that the response of capital flows to a eurozone interest rate shock is most intensive in Bulgaria and the Baltic countries, and least intensive in Poland. Responses of capital flows to a domestic interest rate shock are on average somewhat weaker. They are most intensive in Latvia, Bulgaria and the Czech Republic, and least intensive in Poland and Croatia.

[FIGURE 6 ABOUT HERE]

In order to check the robustness of the results, VAR models with different order of variables in the Cholesky factorization have also been estimated, e.g. with the exchange rate and/or the domestic interest rate as the variable which precedes the eurozone interest rate in the factorization. But even in these cases, the results and conclusions of the analysis do not change significantly. Results of these estimated models are available upon request.

Robustness checks

In order to determine whether the results of the econometric model confirm the research hypothesis, it is necessary to conduct an extensive robustness check, i.e. to test the degree of capital mobility in analysed countries using some other (un)conventional measures. In this section, the mobility of capital will be tested by the following approaches: measuring the correlation between domestic savings and investment (Feldstein-Horioka regressions), testing of the uncovered interest rate parity hypothesis, and testing whether the trilemma hypothesis holds in practice. It should be noted that each of these measures could be implemented in much more detail and scrutiny than in this paper. However, due to limited space, this could not be done in one paper, and one should bear in mind that these methods only serve as a reference when evaluating the robustness of the results from the econometric model.

Feldstein-Horioka regressions

Testing the degree of capital mobility by measuring the correlation between domestic savings and investments will be carried out by estimating the Feldstein-Horioka regressions on a sample of European post-transitional countries. The following cross-section regression equation has been estimated using ordinary least squares:

$$(I/Y)_i = \alpha + \beta(S/Y)_i + \varepsilon_i \quad (9)$$

where I represents domestic investments, Y gross domestic product, S domestic savings, ε the error term, while α and β are parameters. Regressions including average shares of domestic investments (*I/Y*) and savings (*S/Y*) in GDP have been conducted on a sample of 11 post-transitional countries with the data divided into two sub-periods – the first one between 1995 and 2004, and the second between 2005 and 2011. To increase the number of observations entering the regression and due to the fact that the analysis does not include interest rates data, the three eurozone countries (Estonia, Slovakia and Slovenia) have also been included in the sample. Table 3 shows the descriptive statistics of both variables over two sub-periods. It should be noted that the limitation of the model is a relatively small sample of countries and observations, which is why the regression results should be taken only as suggestive evidence.

[TABLE 3 ABOUT HERE]

Figure 7a shows that in the first sub-period (1995–2004) the slope coefficient is 0.84 and is statistically significant at 1%, with a coefficient of determination of 0.69, which implies that the relatively high share of variation in domestic investments in post-transitional countries can be explained by the variation in domestic savings. According to Feldstein and Horioka, this result would imply a relatively low level of capital mobility in analysed countries, considering that the high degree of capital mobility implies a relatively low share of domestic savings in domestic capital formation, i.e. investments. However, in the second sub-period the slope coefficient falls to 0.61 (significant only at 10%), and the coefficient of determination declines to 0.33 (Figure 7b). This result suggests that the capital mobility has increased in the second sub-period, which may be associated with the accession of post-transitional countries to the European Union and with the continuous increase in the level of their financial integration with old EU member states.

[FIGURE 7 ABOUT HERE]

Cross-section regressions have been estimated for each year in the period 1995–2011, and the resulting coefficients of determination are presented in Figure 8. It is evident that until 2001, with the exception of 1997, a relatively high proportion of domestic investment variations could be explained by the variation in domestic savings (in 2000 as much as 82%). But after 2001 the correlation between the two variables declines, more rapidly after joining the European Union, only to almost completely disappear in the period between 2006 and 2008, as evidenced by R^2s ranging around zero. It was precisely the period 2006–2008 that was marked by the largest amounts of foreign capital flows to European post-transitional countries (Figure 1), and the results shown in Figure 8 confirm the high level of capital mobility and a high degree of financial integration of post-transitional countries during that period.

[FIGURE 8 ABOUT HERE]

The risk of a high exposure to large amounts of capital inflows became apparent during the global financial crisis, resulting in some countries imposing capital controls and reducing their level of *de jure* financial openness (Chinn and Ito 2013), which, accompanied by increased risk aversion in the markets, resulted in increased correlations between domestic savings and investment from 2009 onwards (Figure 8.).

In addition to cross-section regressions, the time series regressions of savings and investment for the period 1995–2011 have also been estimated for all 11 countries separately. The coefficients of determination from estimated equations are presented in Figure 9a. Moreover, correlation coefficients between the two time series have been calculated for the whole period and are shown in Figure 9b. Both indicators provide very similar results, and it is evident that the lowest level of correlation between savings and investment is present in the Baltic countries and Bulgaria, which implies a high degree of capital mobility in these countries. On the other hand, highest coefficients of determination and correlation have been recorded in Slovenia, the Czech Republic and Croatia. It is evident that these results are consistent with the results obtained in the econometric analysis.

[FIGURE 9 ABOUT HERE]

Uncovered interest rate parity

There are several different measures of capital mobility which are based on the rates of return on investments, but their empirical applicability is often limited. The real interest rate differential is not a credible measure of capital mobility due to the fact that the purchasing power parity hypothesis is not supported by actual data (changes in the nominal exchange rates do not reflect differences in inflation rates between countries), and given that the exchange rate risk premium is usually different from zero. Furthermore, covered interest rate parity is applicable only in developed economies, given that forward markets in many developing countries do not exist or are poorly developed, which result in time series too short for empirical analysis. Thus, in order to investigate the degree of capital mobility in European post-transitional economies, the uncovered interest rate parity hypothesis will be tested. If capital mobility is perfect, the difference between the domestic interest rate and the sum of the foreign interest rate and the expected rate of domestic currency depreciation should be equal to zero.

The uncovered interest rate parity hypothesis in European post-transitional economies has been tested by subtracting 3-month EURIBOR from 3-month domestic money market rate.[2] Thus obtained interest rate differential ($i - i^*$) is then reduced by the expected percentage change of the domestic exchange rate against the euro (*UIRP*). It is a model with adaptive expectations, which means that the expected change in the exchange rate in period *t* is equal to the change in the exchange rate in period *t-1*. Estonia, Slovakia and Slovenia have again been removed from the sample, given that they joined the eurozone and took over ECB's interest rates during the analysed period.

Figure 10 gives an overview of *UIRP* movements in European post-transitional countries. If we examine the whole period (1995–2011), it is evident that the hypothesis of uncovered interest parity can be rejected. However, the general downward trend in interest rate differentials over time is clear.

[FIGURE 10 ABOUT HERE]

There were short periods of deviation from this trend during certain sub-periods. These changes are the result of external influences, such as the spillover of financial crises from other countries, but also the result of some domestic factors, such as the decision to change the exchange rate regime, which have had an impact on the movement of the risk premium in some countries. For example, in 1998 there was a short-term increase in the value of interest rate differentials reflecting the Russian financial crisis and the consequent increase in risk premiums in all post-transitional countries.

Throughout most of the 2000s there was a trend of declining interest rate differentials. Meanwhile, Bulgaria and Lithuania have introduced a currency board regime and have pegged their currencies to the euro, which reduced their interest rate differentials to values around zero, but with very low volatility, which brought the uncovered interest rate parity hypothesis in these countries close to reality (Figure 10).

[2] When calculating the uncovered interest rate parity, other interest rates may be considered, e.g. long-term yields on government bonds. However, time series of short-term money market rates provide the largest scope in terms of the number of observations and countries for which the data are available.

Renewed growth in interest rate differentials took place in the last quarter of 2008 due to the spread of the global financial crisis and the sharp increase in the risk premium in all post-transitional countries. The peak was reached in mid-2009, after which they started to decline to pre-crisis levels due to the normalisation of the situation in the financial markets.

Table 4 confirms the above conclusions. It is evident that the values of interest rate differentials and *UIRP* were lower in between 2005:Q1 and 2008:Q3 than in the preceding period. But the outbreak of the global financial crisis in late 2008 turned the trend as average values of interest rate differentials and *UIRP* became significantly higher than in the pre-crisis period.

[TABLE 4 ABOUT HERE]

Table 4 also allows for the comparison of the degrees of capital mobility across analysed countries. Displayed values confirm the results obtained by the econometric model and Feldstein-Horioka regressions, since the highest degrees of capital mobility were recorded in Bulgaria and the Baltic countries. These countries, on average, recorded lowest values of *UIRP* in pre- and post-crisis periods and were closest to the realisation of the uncovered interest rate parity. The results are also similar in the case of Romania, Poland and, in the post-crisis period, Croatia. These countries recorded relatively high values of correlation between domestic investment and savings, but also of interest rate differentials and *UIRP*. The differences, however, are visible in the case of the Czech Republic and Hungary, whose indications of the degree of capital mobility, as measured by interest rate differentials, are different from those obtained from the econometric model and Feldstein-Horioka regressions. Specifically, the interest rate differentials suggest a relatively high degree of capital mobility in the Czech Republic and low in Hungary, which is in contrast with the results obtained by previous measures of capital mobility.

Finally, it can be concluded that the uncovered interest rate parity hypothesis does not have an empirical confirmation in the case of European post-transitional countries. This is an expected finding given the fact that the currencies of these countries are not perfect substitutes, and given the present risk aversion amongst foreign investors which was reflected in the risk premium on investments in analysed countries. These premiums have significantly increased during periods of financial crises and economic instabilities, which was reflected in increased values of interest rate differentials relative to the eurozone. Uncovered interest rate parity, i.e. perfect capital mobility, does not exist even in countries where all barriers to the free flow of capital have been removed, i.e. in countries where the level of *de jure* financial openness is the highest possible. However, the movements of interest rate differentials suggest that the capital mobility in European post-transitional countries over the past 15 years has had a rising trend. Deviations from this trend were short-lived and were the result of the aforementioned changes in domestic and international circumstances.

The trilemma hypothesis

The third measure used for the robustness check of the results from the econometric model is not conventional, and so far has not been used in the literature. The trillema hypothesis implies that if the government wants to fully accomplish two objectives of the impossible trinity, the third one must completely give up. If this restriction is quantified in a way that the achievement of each of the three objectives is labelled with separate indices, such that each index assumes a value between 0 and 1 (where 1 indicates the full realisation of each objective, and 0 the complete lack of its realisation), it could be derived from the theory of the trilemma that the sum of three indices should be approximately equal to 2:

$$EXR_t + SOV_t + OPN_t \cong 2 \qquad (10)$$

where EXR_t indicates the exchange rate stability index, SOV_t monetary sovereignty index, and OPN_t financial openness index, i.e. a *de jure* measure of capital mobility. Aizenman *et al.* (2010) created the

trilemma indices which quantify the extent to which countries achieve each of the three objectives of the impossible trinity. Higher values of indices indicate a higher level of financial openness of the country, measured by the Chinn-Ito index based on the data in IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER); higher exchange rate stability, measured by its standard deviation; and higher degrees of monetary sovereignty, measured by the correlation between the domestic short-term interest rates and the corresponding interest rates in the base country.[3]

The high levels of financial openness as a precondition for EU membership has forced the governments in post-transitional countries to choose from and/or balance between two remaining objectives of the trilemma – exchange rate stability and monetary sovereignty. Estonia, Slovakia and Slovenia, meanwhile, have joined the eurozone and thus fixated the value of *EXR* to 1, and by losing monetary sovereignty, the value of *SOV* to 0. Similar values refer to Bulgaria and Lithuania, countries with the currency board regime, but still with a relatively high level of monetary sovereignty in Bulgaria, i.e. relatively low correlation between domestic interest rates and eurozone interest rates. On the other hand, Romania has chosen the opposite strategy and let the exchange rate fluctuate freely, at the cost of giving up the determination of interest rates. However, most countries (Czech Republic, Croatia, Latvia, Hungary, Poland) have chosen to balance between the two objectives, but still with a trend of gradual loss of monetary sovereignty.

The trilemma indices tell a somewhat different story than the one assumed by theoretical aspects of the impossible trinity hypothesis and Equation (10). The deviation of the sum of trilemma indices from theoretically assumed values, marked as DEV_t, where:

$$DEV_t = |2 - (EXR_t + SOV_t + OPN_t)| \qquad (11)$$

should in theory be equal to or near 0. However, the aforementioned deviation has very rarely been equal to theoretically assumed values, and in some countries, e.g. Poland, extremely high, even exceeding 1 (Table 5). This suggests that the trilemma hypothesis is based on too strong assumptions. Specifically, if capital mobility is not perfect, capital flows will not be motivated solely by the movement of interest rates and by the maximisation of the portfolio profitability. Instead, factors like risk aversion, animal spirits and boom-bust cycles in source countries will have a more pronounced impact on capital flows volatility, which has not been considered in the theory of the impossible trinity.

[TABLE 5 ABOUT HERE]

Measuring of *DEV* may be used as an alternative method for estimating the degree of capital mobility. Table 5 displays the average values of *DEV* in European post-transitional countries in three different sub-periods. The average deviation of the sum of trilemma indices from theoretically assumed values was significantly reduced in the period 2004–2007 in all analysed countries compared to the transition and pre-accession period (1996–2003). In the third sub-period, 2008–2010, the deviation increased again, which is a clear consequence of the financial crisis.[4]

Moreover, Figure 11 shows that the average deviation of the sum of trilemma indices has been lowest in the Baltic countries and Bulgaria over the entire analysed period. Such temporal and spatial dynamics of *DEV* is consistent with previously used measures of capital mobility and suggests that its level can be adequately estimated in this way as well.

[FIGURE 11 ABOUT HERE]

[3] For more details on the construction of indices see Aizenman *et al.* (2010), also available from: http://web.pdx.edu/~ito/w14533.pdf [Accessed 6 September 2013].

[4] Table 5 reveals a decrease in average values of *DEV* in the Czech Republic and Slovakia during the last sub-period, when compared to 2004–2007. The value of the deviation, however, even in these countries increased in 2008, reflecting the financial crisis, but low levels of deviation in 2009 and 2010 lowered the average values below the 2004–2007 level.

These findings suggest that the trilemma hypothesis was closest to reality in the mid-2000s, i.e. after the majority of post-transitional countries joined the EU, until the outbreak of the global financial crisis. Since the assumption of high sensitivity of capital flows to changes in interest rates is the underlying assumption of the impossible trinity hypothesis, this finding also points to the conclusion that the sensitivity of capital flows to changes in interest rates was strongest precisely during the aforementioned period, which is exactly the result that has been obtained by the econometric analysis.

Conclusion

The aim of this paper was to test the hypothesis that the degree of capital mobility can be estimated by the reaction intensity of capital flows to shocks in domestic and foreign interest rates, which was tested on a sample of eight European post-transitional countries. The hypothesis was derived directly from the Mundell-Fleming open economy model and is the fundamental premise of the monetary trilemma hypothesis.

A four variable VAR model has been estimated and the historical decomposition analysis has shown a significant increase in the significance of interest rate shocks for the movement of total net capital flows to post-transitional countries on the eve of and shortly after their accession to the European Union. On the other hand, the global financial crisis has resulted in the declining sensitivity of capital flows to changes in interest rates due to increased levels of risk aversion on international capital markets. Comparison of the intensity and significance of the reaction of capital flows to changes in interest rates amongst the analysed countries yielded results which suggest that the degree of capital mobility has been the highest in Bulgaria, Latvia, Lithuania, and lowest in Poland and Croatia.

In order to determine whether the results obtained by the econometric model are adequate for estimating the degree of capital mobility, they had to go through a thorough robustness check and had to be compared with other (un)conventional measures of capital mobility. Results of Feldstein-Horioka regressions indicate a significant increase in the mobility of capital in mid-2000s until the outbreak of the global financial crisis, after which the degree of capital mobility decreased again. Similar results were obtained by the testing of uncovered interest rate parity hypothesis. Results indicate an evident trend of declining interest rate differentials in post-transitional countries vis-à-vis the eurozone during most of the analysed period, but with sub-periods of short-term deviations from this trend. These occurred as a result of external influences, such as the spillover of financial crises from neighbouring countries, but also due to some domestic factors, e.g. the decisions to change currency regimes, which have had an impact on the risk premium of individual countries.

Analysis based on the trilemma indices found that the average deviation of the sum of these indices from theoretically assumed values in the 2004–2007 period significantly declined in all analysed countries compared to the transitional and pre-accession period (1996–2003), after which, under the influence of the financial crisis, it increased again. This is consistent with the results of previous measures of capital mobility, but it also suggests that the trilemma hypothesis is based on too strong assumptions. Obviously, capital flows are not necessarily motivated solely by movements in interest rates and by the maximisation of the portfolio profitability. Other factors, such as risk aversion, animal spirits and boom-bust cycles in source countries, can also have a significant impact on their volatility, which has not been considered in the theory of the impossible trinity. The inability to empirically confirm the impossible trinity hypothesis entails a necessity to revisit the conclusions of the Mundell-Fleming model on the inefficiency of fiscal policy in terms of flexible exchange rates, and of monetary policy in terms of fixed exchange rates. The above is potentially a very interesting area for future research.

What is common to all previously used measures of capital mobility is that, at the individual country level, they all suggest that capital mobility was highest in Bulgaria and the Baltic countries (Lithuania and Latvia). On the other side of the spectrum, the rankings change depending on the measurement method, but, on average, the results suggest that the mobility of capital is lowest in Poland and Croatia. These results also indicate different levels of financial integration with EU-15 countries

amongst EU NMS. High degrees of capital mobility, i.e. levels of financial integration, in Bulgaria and in the Baltics could serve as a potential singal of preparedness of these countries to join the monetary union.

Given that the results of the econometric model are largely consistent with the results of alternative measures of capital mobility, it can be concluded that the degree of capital mobility in European post-transitional countries can be adequately estimated by the reaction intensity of capital flows to domestic and eurozone interest rate shocks, i.e. that the main hypothesis and two sub-hypothesis have been confirmed. This paper, therefore, represents a contribution to economic science in the field of empirical measurements of the degree of international capital mobility as it develops a new measure which has not yet been used in the literature.

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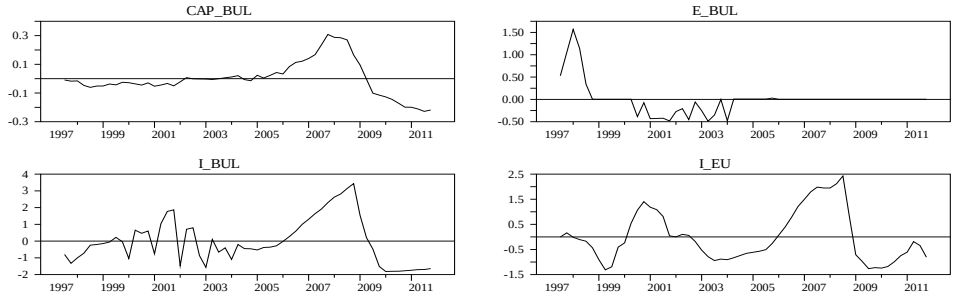
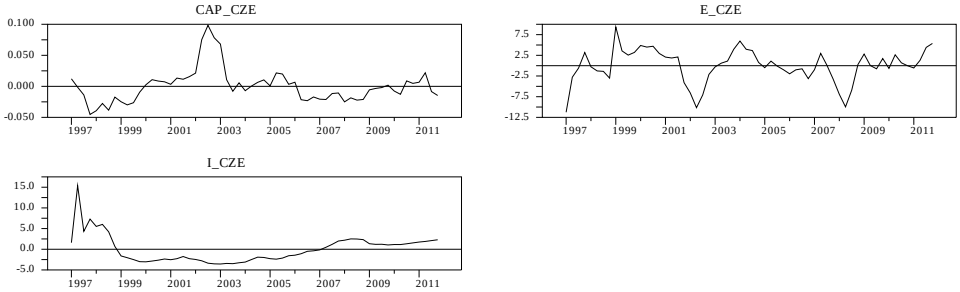
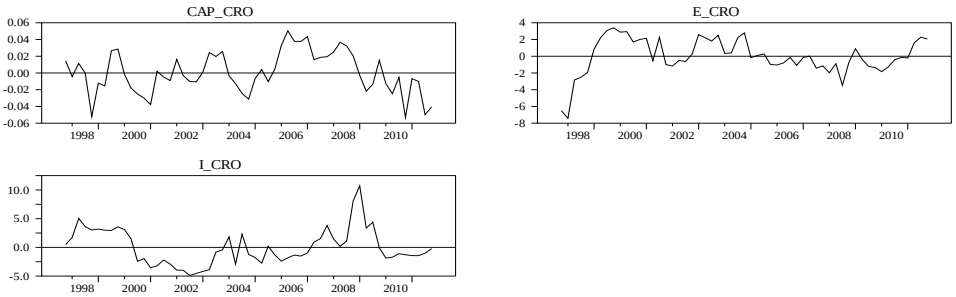


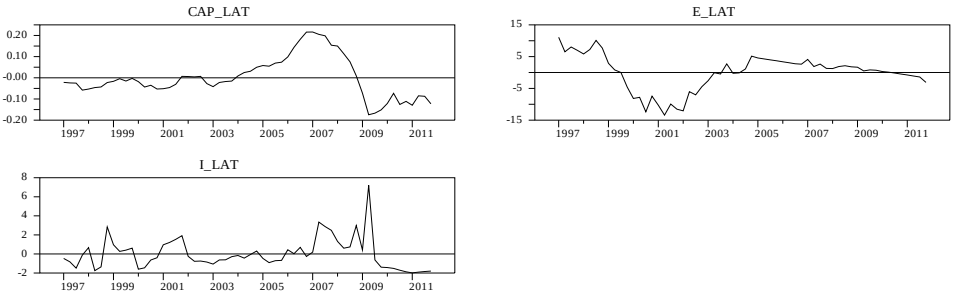
(a) Bulgaria



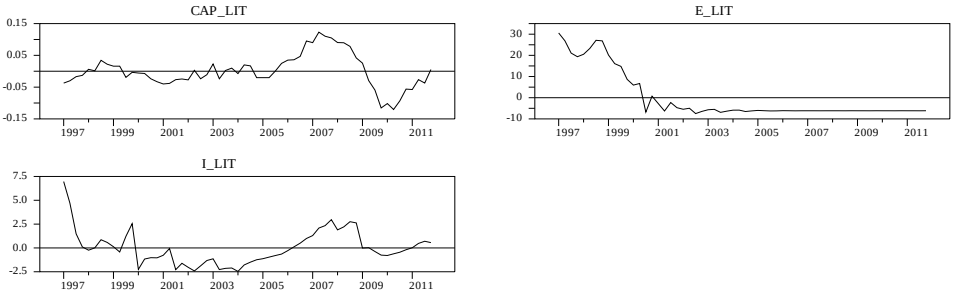
(b) Czech Republic



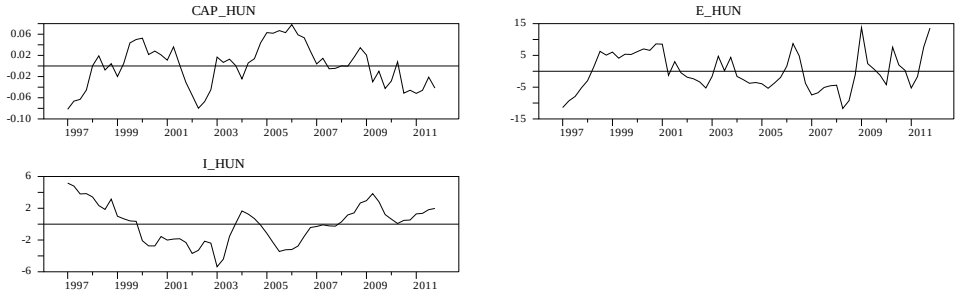
(c) Croatia



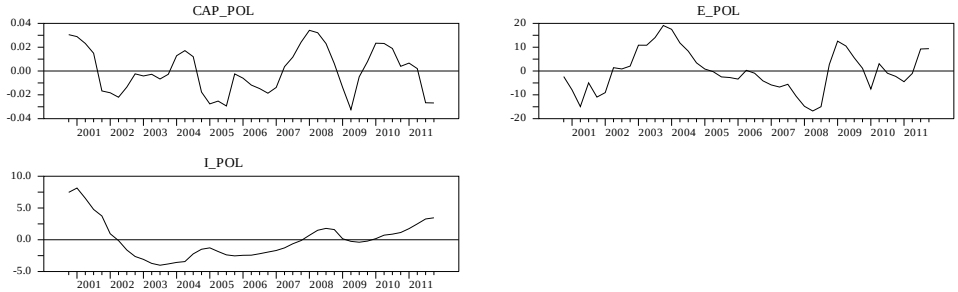
(d) Latvia



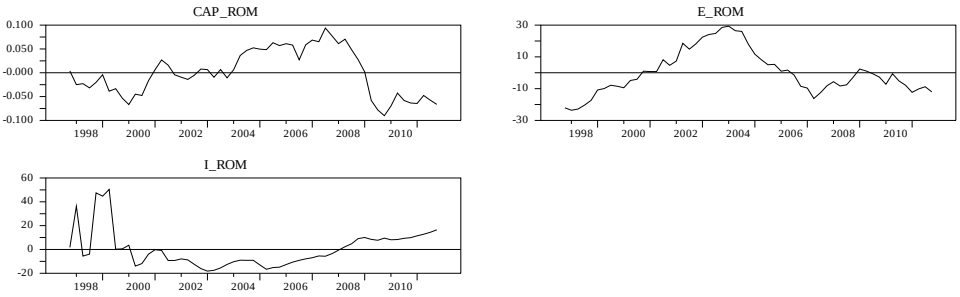
(e) Lithuania



(f) Hungary



(g) Poland



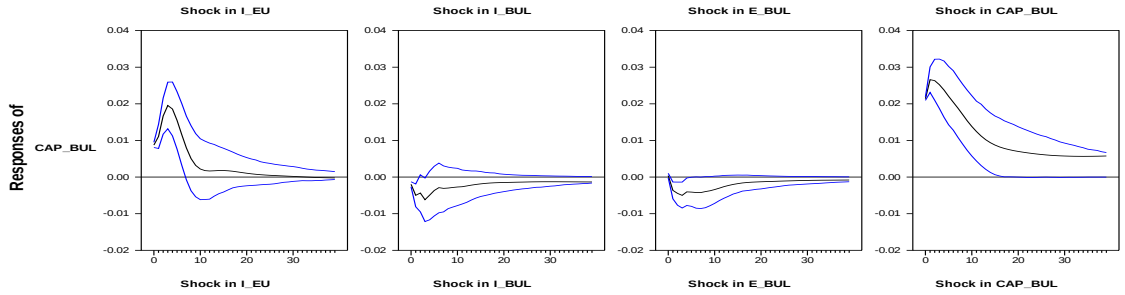
(h) Romania

Figure 1. Time series of variables used in the analysis

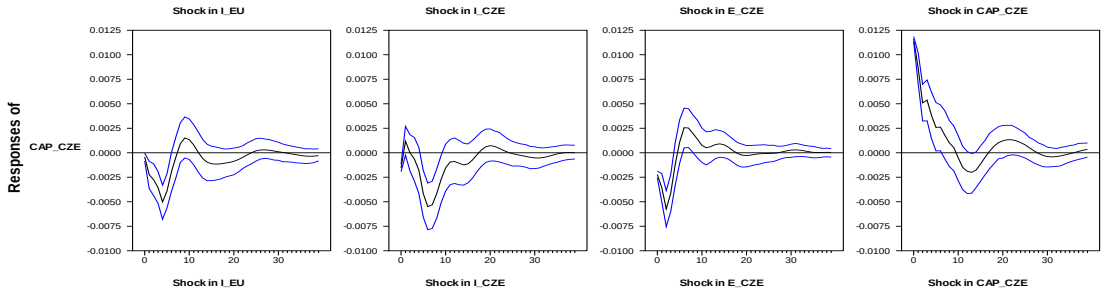
Table 1. Results of the ADF unit root test

Variable	t-statistics	Variable	t-statistics	Variable	t-statistics
Bulgaria		**Czech Republic**		**Croatia**	
CAP_BUL	-2.26*	*CAP_CZE*	-2.10*	*CAP_CRO*	-3.41**
I_BUL	-3.10**	*I_CZE*	-4.67**	*I_CRO*	-2.87**
E_BUL	-3.64**	*E_CZE*	-3.58**	*E_CRO*	-3.73**
Latvia		**Lithuania**		**Hungary**	
CAP_LAT	-2.02*	*CAP_LIT*	-2.08*	*CAP_HUN*	-2.76**
I_LAT	-3.24**	*I_LIT*	-4.48**	*I_HUN*	-2.73**
E_LAT	-3.81**	*E_LIT*	-1.28	*E_HUN*	-2.48*
		ΔE_LIT	-5.84**		
Poland		**Romania**		**Foreign variable**	
CAP_POL	-4.01**	*CAP_ROM*	-1.55	*I_EU*	-2.86**
I_POL	-3.83**	*ΔCAP_ROM*	-6.48**		
E_POL	-2.67**	*I_ROM*	-2.25*		
		E_ROM	-1.52		
		ΔE_ROM	-2.33*		

Note: The non-stationarity hypothesis can be rejected at: **1% significance level; *5% significance level. The number of lags in each ADF regression has been selected by minimizing Akaike and Hannan-Quinn information criteria. Critical values have been generated by the *WinRATS 8* software.



(a) Bulgaria



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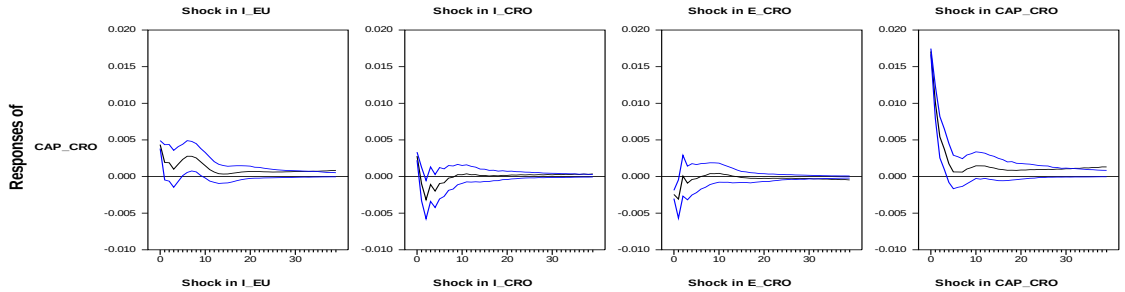

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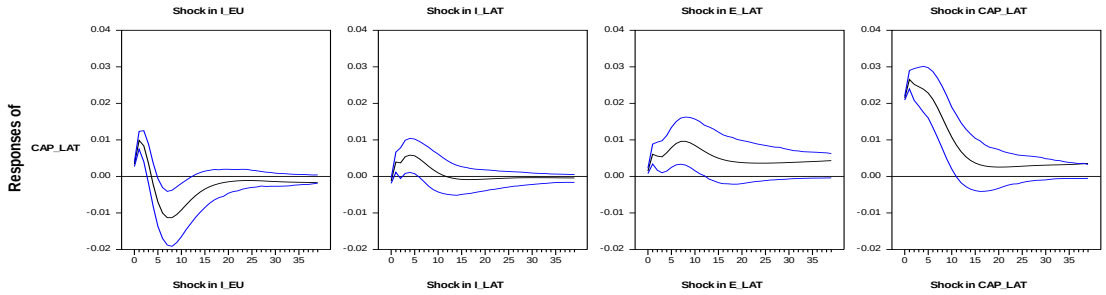
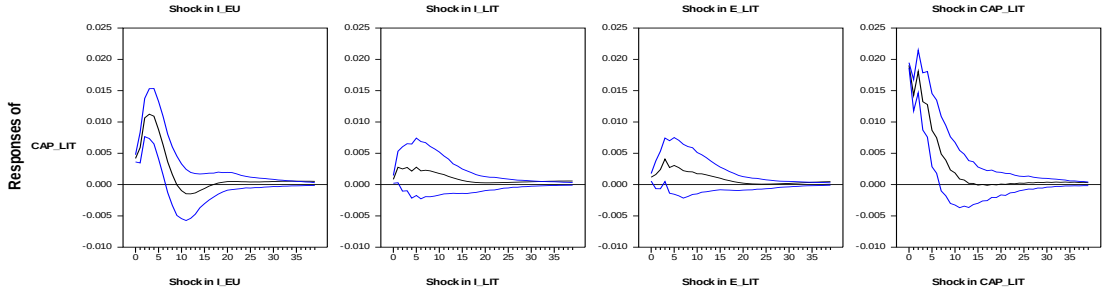
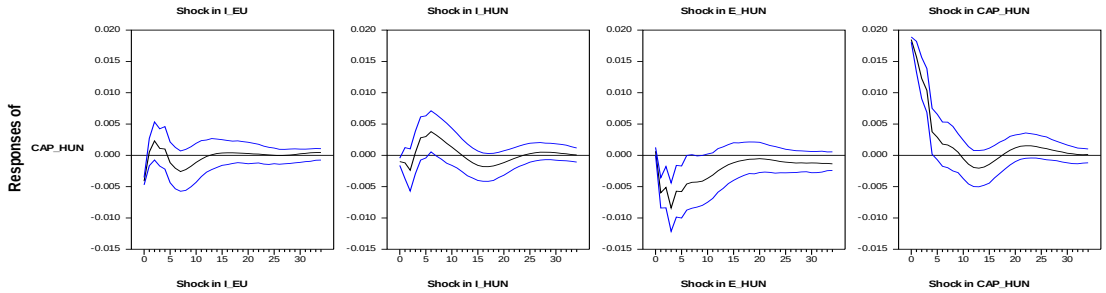


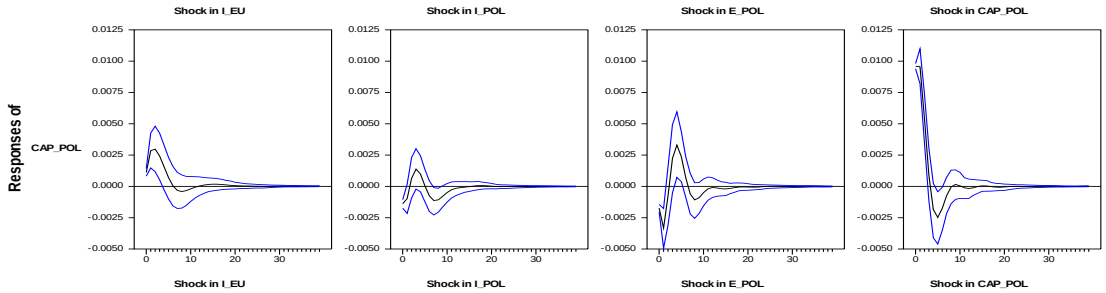
(d) Latvia



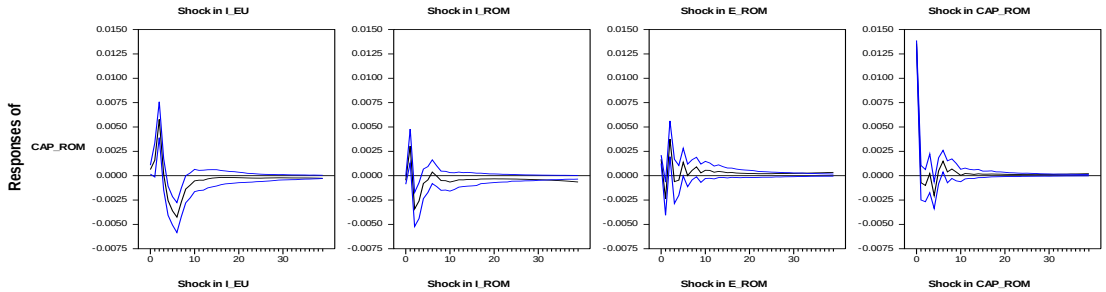
(e) Lithuania



(f) Hungary

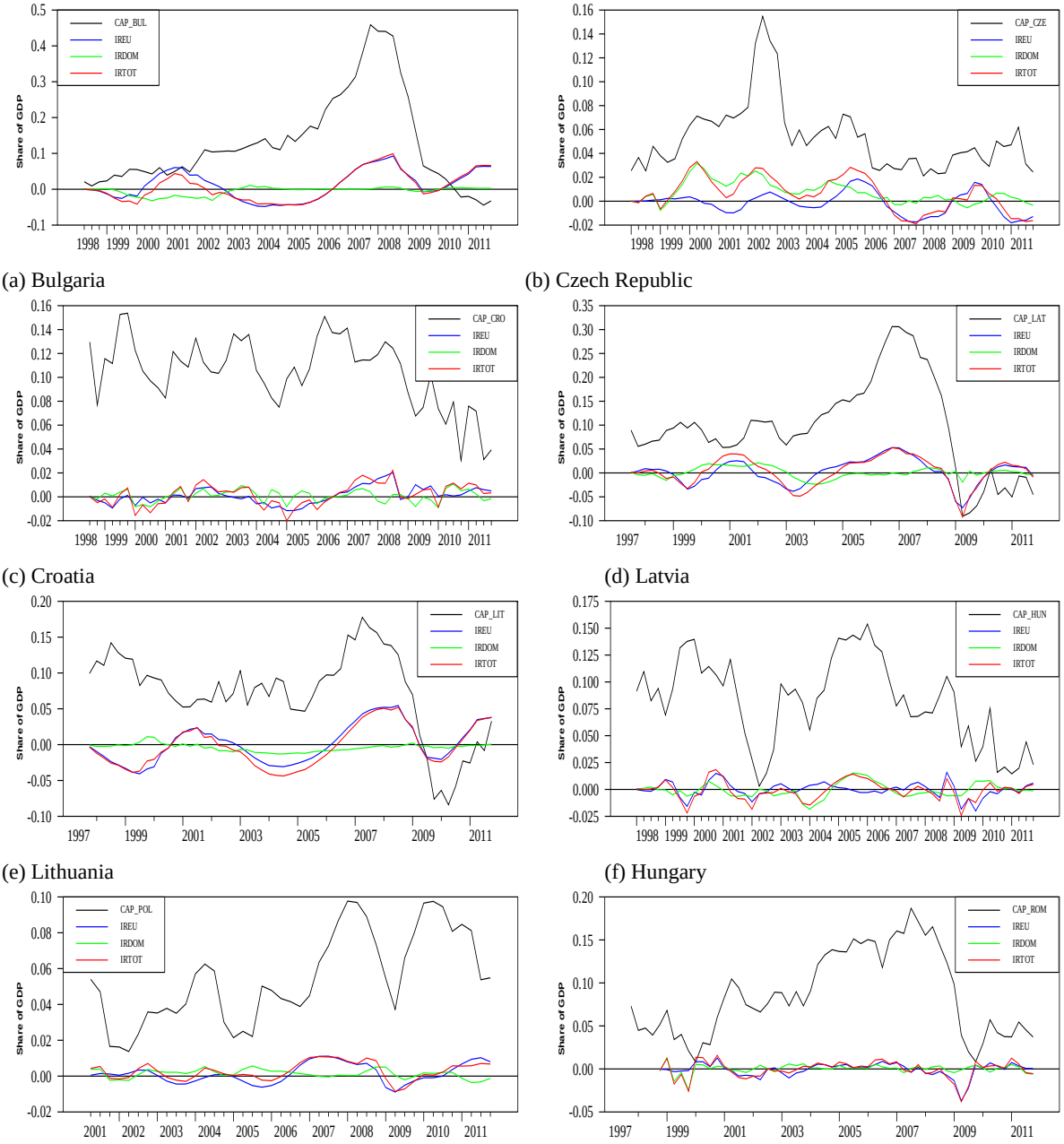


(g) Poland



(h) Romania

Figure 2. Impulse response functions of total net capital flows (one standard deviation shock)



(a) Bulgaria (b) Czech Republic

(c) Croatia (d) Latvia

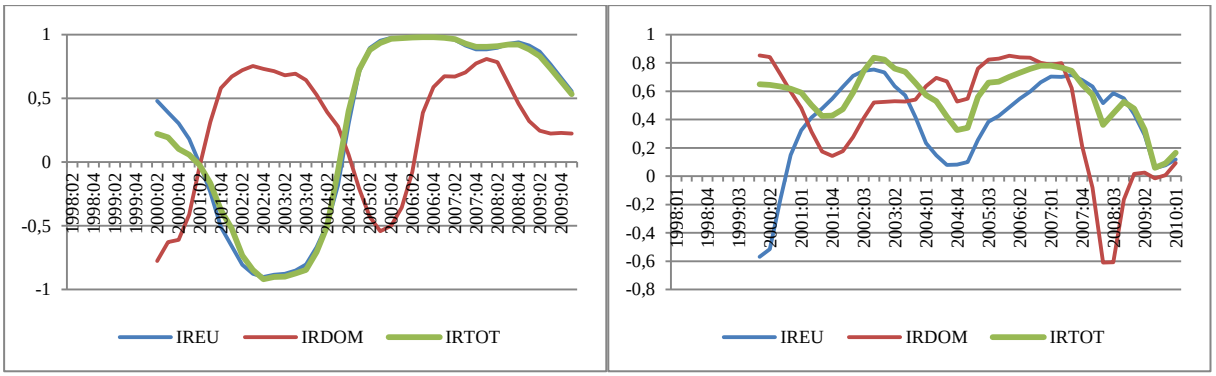
(e) Lithuania (f) Hungary

(g) Poland (h) Romania

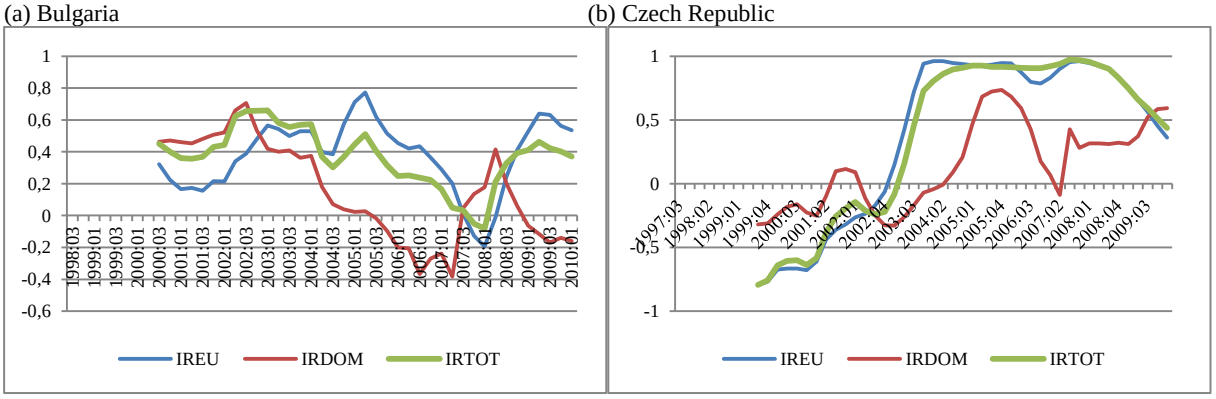
Figure 3. Historical decomposition of total net capital flows to European post-transitional countries

Table 2. Correlation coefficients between actual total net capital flows and components from historical decomposition

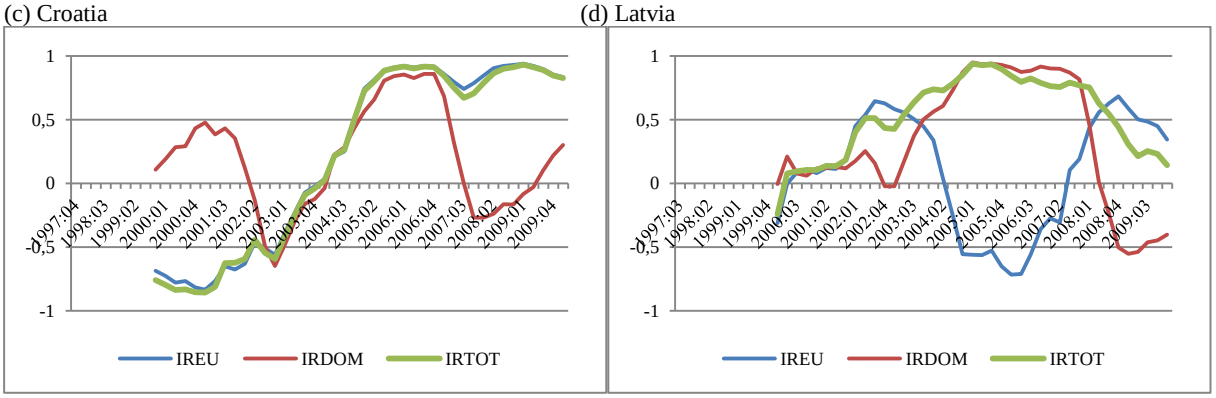
Period	*IREU*	*IRDOM*	*IRTOT*	Period	*IREU*	*IRDOM*	*IRTOT*
Bulgaria				**Czech Republic**			
97:Q1-11:Q4	0.33	0.28	0.41	*97:Q1-11:Q4*	0.27	0.68	0.63
97:Q1-06:Q4	-0.32	0.41	-0.22	*97:Q1-04:Q1*	0.33	0.57	0.67
07:Q1-11:Q4	0.60	0.11	0.57	*04:Q2-11:Q4*	0.39	0.68	0.59
Croatia				**Latvia**			
97:Q1-11:Q4	0.01	0.11	0.08	*97:Q1-11:Q4*	0.62	0.00	0.55
97:Q1-06:Q4	0.39	0.24	0.39	*97:Q1-04:Q1*	-0.38	0.00	-0.30
07:Q1-11:Q4	0.47	0.03	0.42	*04:Q2-11:Q4*	0.75	0.06	0.71
Lithuania				**Hungary**			
97:Q1-11:Q4	0.19	-0.05	0.17	*97:Q1-11:Q4*	0.04	0.20	0.18
97:Q1-04:Q1	-0.62	0.33	-0.54	*97:Q1-04:Q1*	-0.09	0.20	0.04
04:Q2-11:Q4	0.50	-0.24	0.41	*04:Q2-11:Q4*	0.24	0.39	0.55
Poland				**Romania**			
00:Q1-11:Q4	0.36	-0.03	0.38	*97:Q1-11:Q4*	0.13	0.16	0.19
00:Q1-04:Q1	-0.38	0.87	0.31	*97:Q1-06:Q4*	0.19	0.26	0.30
04:Q2-11:Q4	0.38	-0.23	0.33	***07:Q1-11:Q4***	0.09	-0.01	0.09



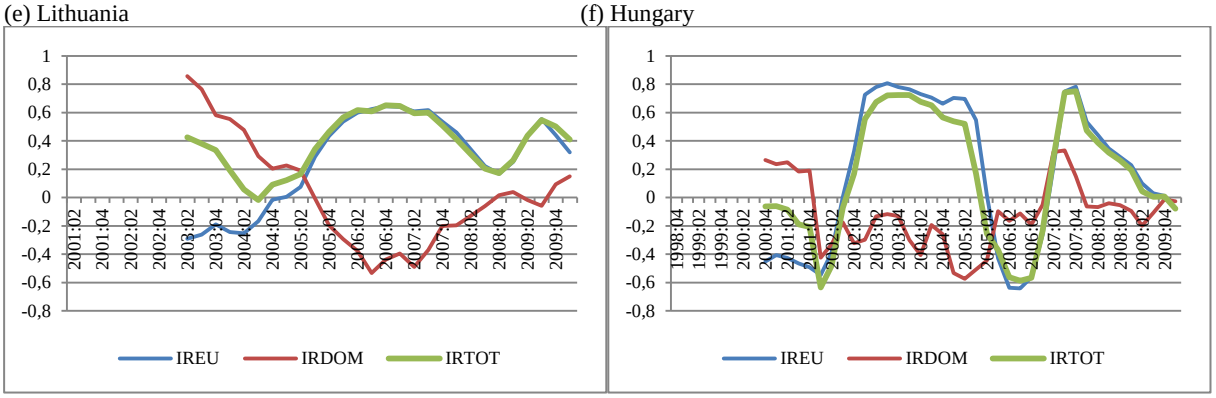
(a) Bulgaria (b) Czech Republic



(c) Croatia (d) Latvia

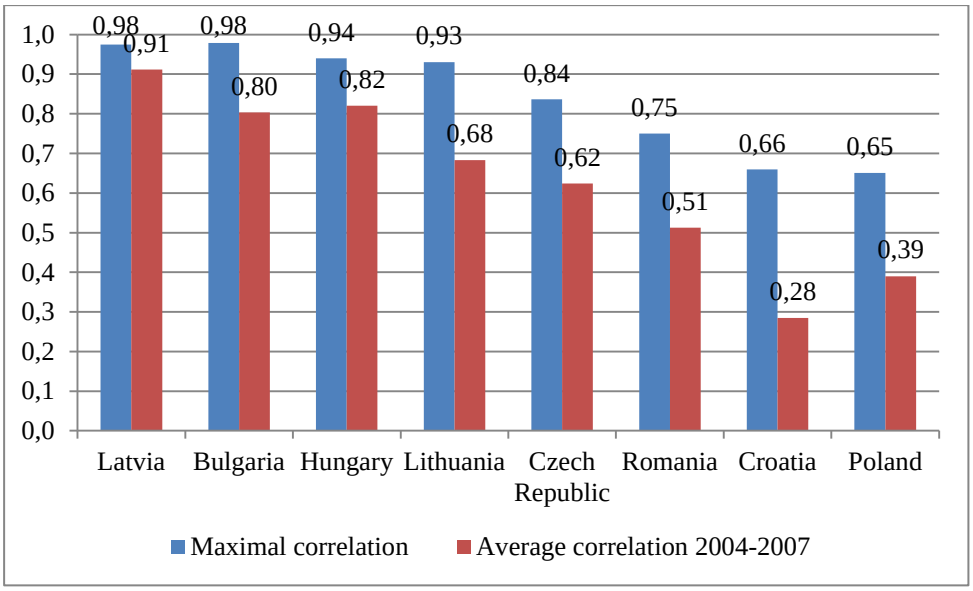


(e) Lithuania (f) Hungary



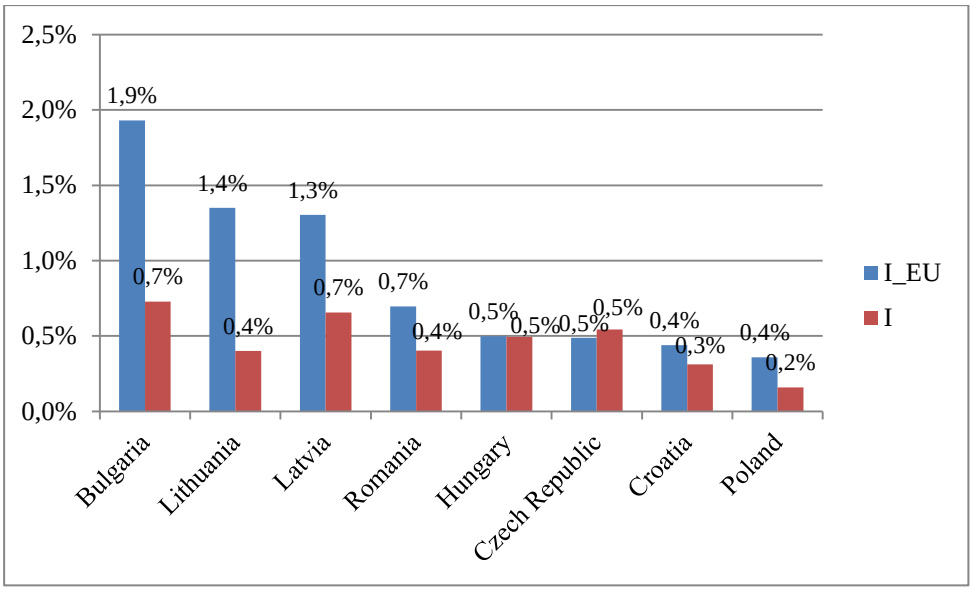
(g) Poland (h) Romania

Figure 4. Dynamic correlation coefficients between actual total net capital flows and components from historical decomposition



Note: Average correlations have been calculated by taking the mean of absolute values of dynamic correlation coefficients for the period 2004:Q1–2007:Q4. Absolute values have been used to avoid biased results in case of negative correlations which would decrease mean levels.

Figure 5. Maximum and average dynamic correlations between *IRTOT* component and actual total net capital flows

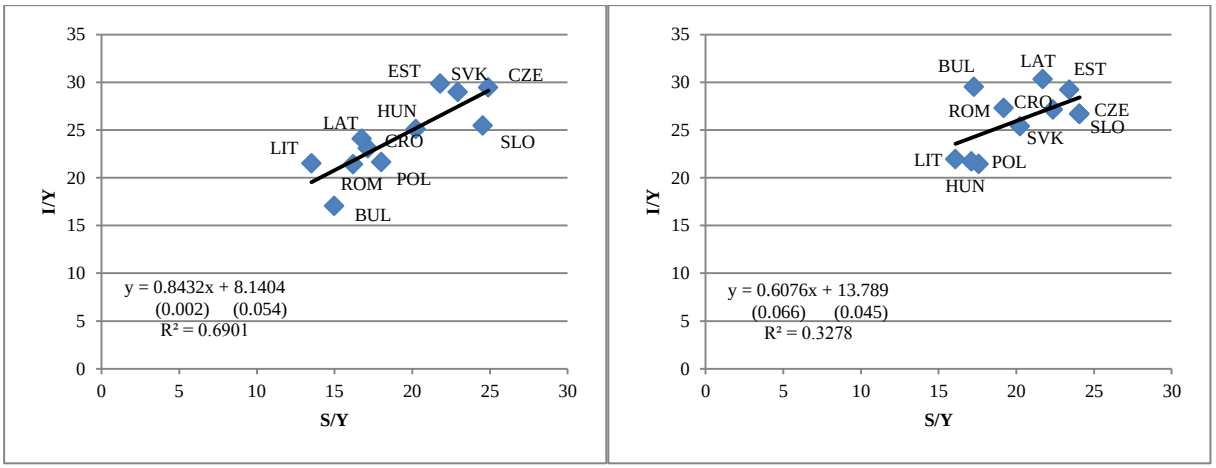


Note: The figure shows absolute values of maximum responses of capital flows to interest rate shocks obtained from impulse response functions (Figure 2). Absolute values have been used for the purpose of easier comparison in case of negative impulse responses.

Figure 6. The level of the maximum response of total net capital flows to shocks in domestic and eurozone interest rates, in per cent of GDP

Table 3. Descriptive statistics of variables from the Feldstein-Horioka regressions

Country	Average (*I/Y*) 1995-2004	Average (*S/Y*) 1995-2004	Average (*I/Y*) 2005-2011	Average (*S/Y*) 2005-2011
Bulgaria	17.05	14.98	29.52	17.27
Czech Republic	29.44	24.89	26.64	24.07
Estonia	29.84	21.79	29.19	23.41
Croatia	23.06	17.14	27.12	22.37
Latvia	24.08	16.76	30.32	21.70
Lithuania	21.51	13.52	21.92	16.08
Hungary	25.08	20.24	21.44	17.58
Poland	21.64	18.01	21.68	17.11
Romania	21.38	16.19	27.28	19.18
Slovakia	28.96	22.94	25.40	20.23
Slovenia	25.45	24.55	26.69	24.05
AVERAGE	**24.32**	**19.18**	**26.11**	**20.28**
ST. DEV.	**3.98**	**3.92**	**3.18**	**3.00**



(a) 1995–2004 (b) 2005–2011

Source: author's calculations, IMF – WEO Database (April 2012)

Figure 7. The relationship between average levels of savings and investment in European post-transitional countries, as a percentage of GDP (p-values in parentheses)

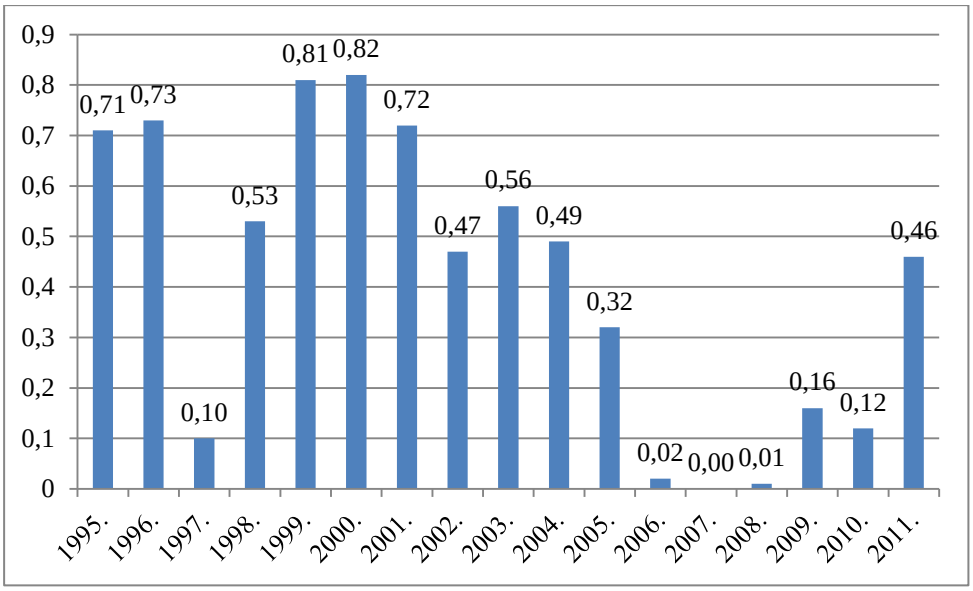
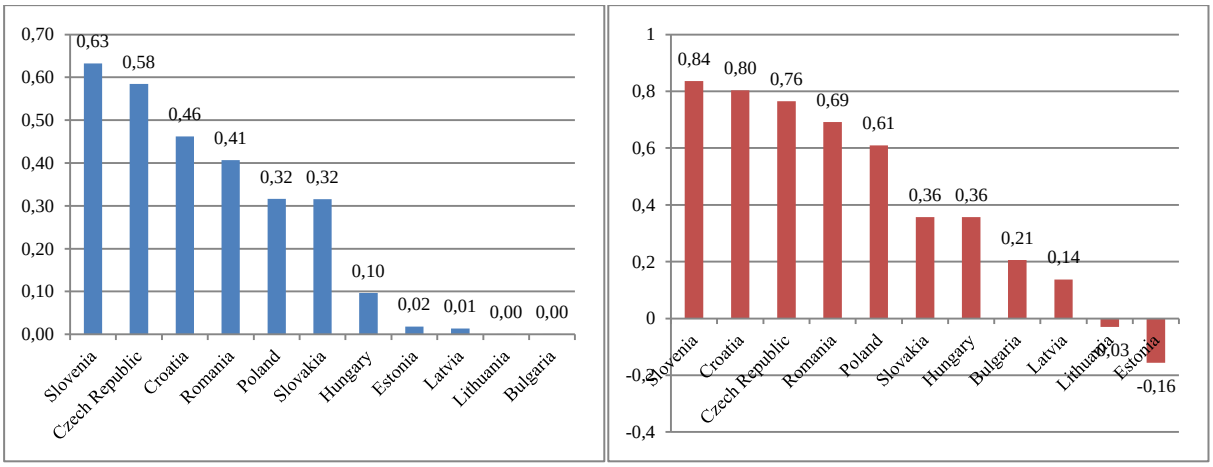
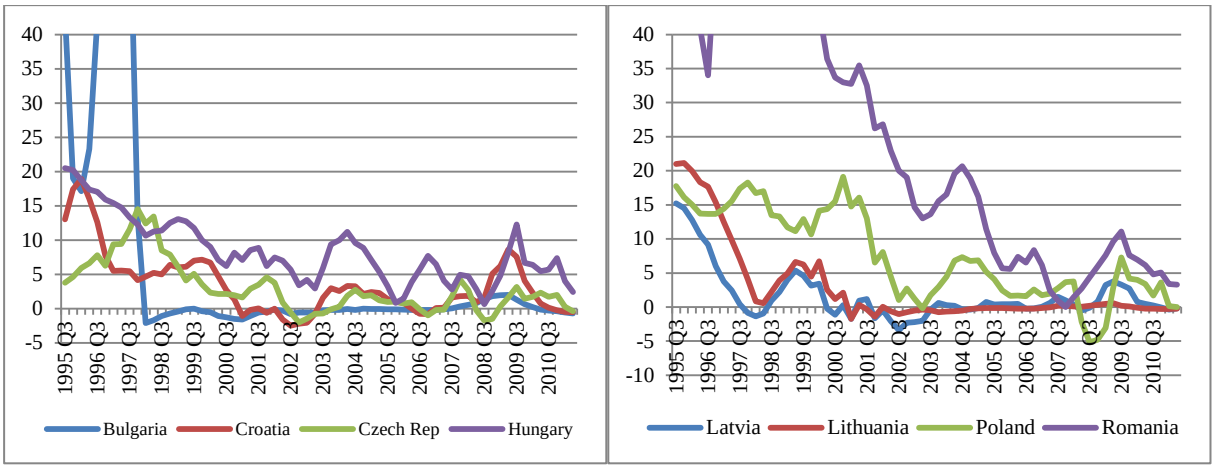


Figure 8. Coefficients of determination obtained from yearly Feldstein-Horioka regressions



(a) Coefficients of determination (b) Coefficients of correlation

Figure 9. Coefficients of determination and correlation from Feldstein-Horioka regressions for the period 1995–2011, by countries



(a) (b)

Source: Eurostat, IMF – IFS, author's calculations

Note: In order to reduce the volatility of time series, the figures show moving annual averages of *UIRP*. For the sake of clarity and comparability, the scale on both panels had to be reduced which is why the values of *UIRP* for Bulgaria and Romania during the 1990s do not fit on the chart.

Figure 10. Testing of the uncovered interest rate parity in European post-transitional countries

Table 4. Testing of the uncovered interest rate parity in European post-transitional countries, by sub-periods

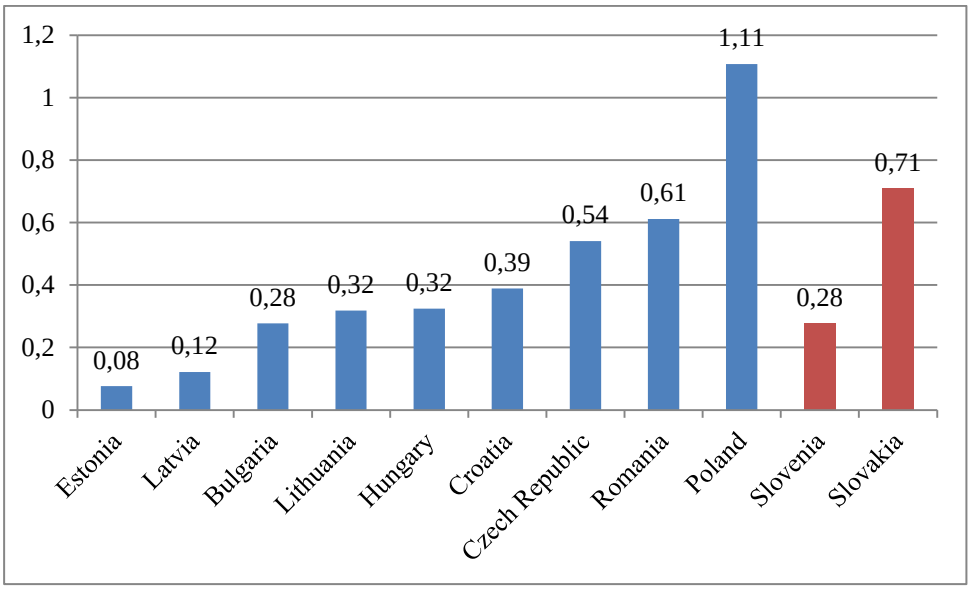
	*i - i**			*UIRP*		
	1995:Q1-2004:Q4	2005:Q1-2008:Q3	2008:Q4-2011:Q4	1995:Q1-2004:Q4	2005:Q1-2008:Q3	2008:Q4-2011:Q4
Bulgaria	21.85	0.10	0.34	14.11	0.10	0.39
Czech Republic	4.01	-0.41	0.83	4.38	0.32	1.18
Croatia	5.09	0.49	3.00	4.81	0.55	2.94
Latvia	2.63	0.34	1.14	2.63	0.22	1.34
Lithuania	4.20	-0.10	0.06	5.23	-0.10	0.04
Hungary	12.10	4.29	6.70	11.02	3.79	5.36
Poland	12.02	1.60	2.79	11.38	1.48	2.10
Romania	47.04	5.44	6.81	40.91	4.84	6.36

Source: author's calculations, Eurostat, IMF – IFS

Table 5. Average deviation of the sum of the trilemma indices from theoretically assumed values (*DEV* = 0)

	1996-2003	2004-2007	2008-2010
Bulgaria	0.63	0.27	0.43
Croatia	0.44	0.30	0.37
Czech Republic	0.70	0.42	0.30
Estonia	0.26	0.16	0.26
Hungary	0.48	0.12	0.28
Latvia	0.27	0.06	0.08
Lithuania	0.28	0.26	0.50
Poland	1.28	0.78	1.10
Romania	0.94	0.21	0.27
Slovakia	0.94	0.45	0.43
Slovenia	0.50	0.09	0.12

Source: author's calculations based on Aizenman *et al.* (2010)



Source: author's calculations based on Aizenman *et al.* (2010)
Note: Slovenia and Slovakia are shown on the right hand side of the figure in order to separate them visually from non-eurozone countries. The same was not done for Estonia since the trilemma indices data cover the period until 2010. Estonia joined the eurozone in 2011.

Figure 11. Average deviation of the sum of trilemma indices from theoretically assumed values, in the period 1996–2010