1. EXCHANGE MARKET PRESSURE AND DE FACTO EXCHANGE RATE REGIME IN THE EURO-CANDIDATES[1]

Daniel STAVÁREK*

Abstract

In this paper we estimate exchange market pressure (EMP) in four euro-candidate countries over the period 1995-2008. We apply model-dependent as well as model-independent approach to the EMP estimation. Since all euro-candidates have to fulfil the exchange rate stability convergence criterion we analyze EMP in context of exchange rate arrangement and develop a continuous measure of de facto exchange rate regime. The paper provides no evidence of serious relationship between EMP and de facto regime. Therefore, the shift towards ERM II should not stimulate EMP to growth and pose an a priori threat to fulfillment of the exchange rate stability criterion.

Keywords: exchange market pressure; de facto exchange rate regime; euro-candidate countries; ERM II

JEL Classification: C32; E42; F31; F36

Introduction

Although the role and significance of the exchange rate development in the monetary policy decisions differs from country to country each monetary authority is concerned, to some degree, about exchange rate and foreign exchange market. Countries under a fixed exchange rate regime have to maintain the central exchange rate parity and act in the foreign exchange market accordingly. On the other hand, open economies following the inflation targeting strategy use exchange rate as one of the factors

[1] *Research behind this paper was supported by the Czech Science Foundation within the project GAČR 402/08/0067 "Financial Integration of the New EU Member States with Eurozone".*

* *Silesian University, School of Business Administration, Department of Finance, Univerzitní nám. 1934/3 733 40 Karviná Czech Republic, tel: +420 596 398 335, fax: +420 596 312 069, e-mail: stavarek@opf.slu.cz.*

included in models forecasting domestic inflation. Therefore, monitoring of the foreign exchange market is crucial for successful and effective monetary policy.

One of the appropriate tools for monitoring of the conditions in the foreign exchange market is the exchange market pressure (EMP). The term “exchange market pressure” is usually related to changes of two cardinal variables describing the external sector of any economy: official international reserve holdings and the nominal exchange rate. The notion of EMP was defined precisely for the first time in Girton and Roper (1977). The EMP index in this study is the simple sum of the rate of change in international reserves and the rate of change in the exchange rate. This construction makes the indicator very universal and conveniently applicable on any exchange rate regime. The feature of generality attracted attention of many researchers and the EMP concept has been widely used and also modified since then.

Despite a great popularity of EMP one can find a very limited number of studies focused on new European Union Member States (NMS). The lack of literature raises the need for analysis of EMP in this region. The need gains even more urgency if the concurrent process of monetary integration in NMS is taken into account. The euro implementation is, however, dependent on the fulfilment of several convergence criteria. One of which is the criterion of national currency’s stability in the period preceding entry into the euro area. The criterion requires participation in the Exchange Rate Mechanism II (ERM II) and respecting normal fluctuation margins without severe tensions for at least two years before examination of the criteria fulfilment.

The aim of this paper is to estimate EMP in the Czech Republic, Hungary, Poland and Slovakia (hereafter EU4) over the period of more than 13 years (first quarter of 1995 – first quarter of 2008). Consequently, we will be able to judge whether EU4 tend to face with excessive EMP that could pose a threat to fulfilment of the exchange rate stability criterion. We apply alternative estimation methods to test their compatibility in the environment of transition countries. Since the convergence criterion includes the requirement of participation in ERM II we present the EMP estimations in context of development of the exchange rate arrangement. Instead of conventional de jure classification we apply a continuous measure of de facto exchange rate regime. Thus, we examine whether de jure regime corresponds with the real exchange rate policy and what is the impact of shifts in the exchange rate arrangement on EMP.

The remainder of the paper is structured as follows. Section 1 describes the meaning and theoretical concepts of the EMP and provides a review of the relevant literature. In Section 2, the models and data used are cited; Section 3 reports the empirical results; and the paper ends with conclusions.

1. Exchange Market Pressure and Literature Review

1.1 Meaning and Concepts of Exchange Market Pressure

As mentioned above, the original concept of EMP was proposed in Girton and Roper (1977). The authors derived the measure from a simple monetary model of the balance of payments. The next step in development of EMP was taken by Roper and Turnovsky (1980) and Turnovsky (1985). They introduced the idea of using a small open-economy model and extended the original model by substituting the simple monetary approach by an IS-LM framework with perfect mobility of capital. Furthermore, the two EMP components were no longer equally weighted as in the Girton-Roper model.

A notable contribution to the EMP theory was provided by Weymark (1995, 1997a, 1997b, 1998). She revised the models mentioned above and introduced a more general framework in which the models are both special cases of the generalized formula. She introduced and estimated a parameter (conversion factor) standing for the relative weight of exchange rate changes and intervention in the EMP index. Since all previous EMP definitions stemmed from a specific model, Weymark also proposed a model-independent definition of EMP as:

The exchange rate change that would have been required to remove the excess demand for the currency in the absence of exchange market intervention, given the expectations generated by the exchange rate policy actually implemented (Weymark 1995, p.278).

Many researchers have criticized the most undesirable aspect of the EMP measure, dependency on a particular model, and proposed some alternative approaches called model-independent. A simpler and model-independent EMP measure was originally constructed in Eichengreen *et al*. (1994, 1995). According to this approach EMP is a linear combination of a relevant interest rate differential, the percentage change in the bilateral exchange rate and the percentage change in foreign exchange reserves. Contrary to Weymark's approach, the weights are to be calculated from sample variances of those three components with no need to estimate any model.

The measure by Sachs *et al*. (1996) consists of the same elements but each weight in the EMP index is calculated with respect to standard deviations of all components included instead of using only standard deviation of the respective component.

Kaminsky *et al*. (1998) and Kaminsky and Reinhart (1999) substituted the interest rate differential by a relevant interest rate in the country analyzed. Furthermore, the weights on the reserves and interest rate terms are the ratio of the standard error of the percentage change of the exchange rate over the standard error of the percentage change of reserves and the interest rate differential respectively. An approach stemming from Eichengreen *et al*. (1996) was also followed by Pentecost et al. (2001). However, they determined the weights using principle components analysis.

1.2 Review of Relevant Empirical Literature

Whereas some empirical papers are focused straight on estimation of EMP in a variety of regions and countries, other studies use the EMP measure as an element of a subsequent analysis examining currency crises, monetary policy, foreign exchange intervention, exchange rate regime and other issues. We only refer to studies analyzing EMP in EU4 in the following literature review.

The first study estimating EMP in, among others, Czech Republic and Poland was Tanner (2002). Using the Girton-Roper model, he examined the relationship between EMP and monetary policy in a vector autoregression system. Regarding the EMP calculated in the Czech Republic and Poland, they were modest as compared to other countries and very similar to each other. However, EMP in Poland was twelve times higher than in the Czech Republic during the Asian crisis in the second half of the 1990s. Although a positive relationship between EMP and domestic money supply was revealed in both countries they were not as significant and straight as in other countries.

A more specific application of the Tanner (2002) approach is Bielecki (2005). The paper concentrates only on Poland from 1994-2002. The results indicate that domestic credit reacted in a counter direction to innovations to EMP. Furthermore, Bielecki compared two EMP measures calculated under alternative methodologies (using all foreign reserve changes and pure official foreign exchange intervention data) and came to the conclusion that the appreciation pressure prevailed over the sample period. However, using the pure intervention data in the EMP estimation provided more realistic and robust results.

Van Poeck *et al*. (2007) used EMP as an indicator of currency crisis and addressed the question whether currency crises in the euro-candidate countries have been more frequent in fixed, intermediate or flexible exchange rate arrangements. The authors found that EMP was higher in intermediate regimes than in extreme arrangements. Likewise, countries with intermediate regimes experienced more currency crises. Regarding EU4, the most crisis quarters (excessive EMP) occurred in Hungary during the fixed peg regime and in Poland when a crawling peg was being applied. Based on a number of regressions explaining EMP by a set of fundamental variables the authors conclude that EU4 should not enter ERM II before their fundamentals are in "safe" region so that they are less candidate for speculation attacks.

Very similar conclusions on altitude and behaviour of EMP were drawn in Stavárek (2006) where EMP in the Czech Republic, Hungary, Poland and Slovenia in 1993-2004 are estimated. The study applied the EMP measure proposed in Eichengreen et al. (1995) and the results obtained suggest that the Czech Republic and Slovenia went through considerably less volatile development of EMP than Hungary and Poland.

2. Measuring the Exchange Market Pressure: Model and Data

2.1 Model-Dependent Approach

This study originally stems from Weymark (1995) and Spolander (1999) and applies the following formula for EMP calculation:

$$EMP_t = \Delta e_t + \eta(1-\lambda)\Delta r_t \tag{1}$$

where: Δe_t is the percentage change in exchange rate expressed in direct quotation (domestic price for one unit of foreign currency), Δr_t is the change in foreign exchange reserves scaled by the one-period-lagged value of money base and η is the conversion factor which has to be estimated from a structural model of the economy and λ is the proportion of foreign exchange intervention that is sterilized by a change of domestic credit.

The conversion factor represents elasticity that converts observed reserve changes into equivalent exchange rate units. This EMP formula assumes that the central bank's monetary policy is completely independent of demand and supply conditions for the domestic currency in the international foreign exchange market. This means that autonomous money market interventions, i.e. changes in domestic credit not due to sterilization operations, are not assumed to be an instrument of exchange rate policy (Spolander 1999, p. 23). Thus, central bank intervenes in domestic money market to provide or restrict liquidity of the banking sector not to influence exchange rate or eliminate EMP.

For practical estimation of EMP the small open economy monetary model summarized in equations (2)-(8) was applied.

$$\Delta m_t^d = \beta_0 + \Delta p_t + \beta_1 \Delta c_t - \beta_2 \Delta i_t \tag{2}$$

$$\Delta p_t = \alpha_0 + \alpha_1 \Delta p_t^* + \alpha_2 \Delta e_t \tag{3}$$

$$\Delta i = \Delta i_t^* + E_t(\Delta e_{t+1}) - \Delta e_t \tag{4}$$

$$\Delta m_t^s = \Delta d_t^a + (1-\lambda)\Delta r_t \tag{5}$$

$$\Delta r_t = -\overline{p}_t \Delta e_t \tag{6}$$

$$\Delta d_t^a = \gamma_0 + \Delta y_t^{trend} + (1-\gamma_1)\Delta p_t - \gamma_2 y_t^{gap} \tag{7}$$

$$\Delta m_t^d = \Delta m_t^s \tag{8}$$

where: p_t is domestic price level, p_t^* is foreign price level, e_t denotes exchange rate (in direct quotation), m_t is nominal money stock (the superscript *d* represents the demand and *s* the supply), c_t is real domestic income, i_t is nominal domestic interest rate, i_t^* denotes nominal foreign interest rate, $E_t(\Delta e_{t+1})$ is expected exchange rate change and λ is proportion of sterilized intervention. All variables up to this point are expressed in natural logarithm. Next, d_t^a is autonomous domestic lending by the central bank and r_t is the stock of foreign exchange reserves, both divided by the one period lagged value of the money base. y_t^{trend} is the long-run trend component of real domestic output y_t and y_t^{gap} is the difference between y_t and y_t^{trend}. The sign Δ naturally denotes change in the respective variable.

Equation (2) describes the changes in money demand as a positive function of domestic inflation and changes in real domestic income and a negative function of changes in the domestic interest rate. Equation (3) defines the purchasing power parity condition attributing the primary role in domestic inflation determination to exchange rate changes and foreign inflation. Equation (4) describes uncovered interest rate parity. Equation (5) suggests that changes in the money supply are positively influenced by autonomous changes in domestic lending and non-sterilized changes in the stock of foreign reserves. Equation (6) states that changes in foreign exchange reserves are a function of the exchange rate and a time-varying response coefficient. Equation (7) describes the evolution of the central bank's domestic lending. Whereas domestic inflation and changes in trend real output changes are positive determinants of the domestic lending the gap between real output and its trend has a negative impact on domestic lending activity. Equation (8) defines a money market clearing condition that assumes money demand to be continuously equal to money supply.

By substituting equations (3) and (4) into equation (2) and substituting equation (7) into equation (5) and then using the money market clearing condition in equation (8) to set the resulting two equations equal to one another, it is possible to obtain the following relation:

$$\Delta e_t = \frac{X_t + \beta_2 E(\Delta e_{t+1}) + (1-\lambda)\Delta r_t}{\gamma_1\alpha_2 + \beta_2} \tag{9}$$

where:

$$X_t = \gamma_0 - \gamma_1\alpha_0 - \beta_0 + \Delta y_t^{trend} - \gamma_1\alpha_1\Delta p_t^* - \gamma_2 y_t^{gap} - \beta_1\Delta c_t + \beta_2\Delta i_t^* \tag{10}$$

and the elasticity needed to calculate EMP in equation (1) can be found as:

$$\eta = -\frac{\partial\Delta e_t}{\partial\Delta r_t} = -\frac{(1-\lambda)}{\gamma_1\alpha_2 + \beta_2} \tag{11}$$

2.2 Model-Independent Approach

Eichengreen *et al*. (1994, 1995) argued that dependency on a particular model was an undesirable feature for EMP index. As an alternative, they proposed the following measure of a speculative pressure:

$$EMP_t = \frac{\Delta e_t}{e_t} - \frac{1}{\sigma_r}\left(\frac{\Delta rm_t}{rm_t} - \frac{\Delta rm_t^*}{rm_t^*}\right) + \frac{1}{\sigma_i}(\Delta(i_t - i_t^*)) \tag{12}$$

where: σ_r is the standard deviation of the difference between the relative changes in the ratio of foreign reserves and money (money base) in the analyzed country and the reference country $\left(\frac{\Delta rm_t}{rm_t} - \frac{\Delta rm_t^*}{rm_t^*}\right)$ and σ_i is the standard deviation of the nominal interest rate differential $(\Delta(i_t - i_t^*))$. Other variables are as defined in the previous specification.

However, for the practical calculation we took an inspiration from Sachs *et al*. (1996) and made some modifications of the EMP formula. In order to avoid the EMP measure being driven by the most volatile component we changed the weighting scheme. We also abandoned the relation between foreign reserves and money in home and reference country. Consequently, the EMP formula based on model-independent approach can be written as follows:

$$EMP_t = \left(\frac{1/\sigma_e}{((1/\sigma_e) + (1/\sigma_{rm}) + (1/\sigma_i))} \right) \frac{\Delta e_t}{e_{t-1}} - \left(\frac{1/\sigma_{rm}}{((1/\sigma_e) + (1/\sigma_{rm}) + (1/\sigma_i))} \right) \frac{\Delta rm_t}{rm_{t-1}} + + \left(\frac{1/\sigma_i}{((1/\sigma_e) + (1/\sigma_{rm}) + (1/\sigma_i))} \right) (\Delta(i_t - i_t^*)) \quad (13)$$

where: σ_e is the standard deviation of the rate of change in the exchange rate $\frac{\Delta e_t}{e_{t-1}}$ and other variables are denoted consistently with (12).

The samples of data used in this paper cover the period 1995:1 to 2008:1 yielding 53 quarterly observations for all EU4 countries. The data were predominantly extracted from the IMF's International Financial Statistics and the Eurostat's Economy and Finance database. The missing observations in the time series were replenished from databases accessible on the EU4 central banks' websites. The detailed description of all data series and their sources is presented in Appendix 1.

3. Estimation of Exchange Market Pressure

3.1 Application of Alternative Approaches

First, we estimate EMP using the model-dependent approach. As is evident from the model presented in Section 3.1, the EMP estimation (1) must be preceded by the calculation of the conversion factor η (11). This step is, however, required to obtain values of the sterilization coefficient λ (5), the elasticity of the money base with respect to the domestic price level γ_1 (7), the elasticity of the domestic price level with respect to the exchange rate α_2 (3), and the elasticity of the money demand with respect to the domestic interest rate β_2 (2).

More precisely, the parameter estimates are obtained by estimating the following three equations.

$$\Delta m_t - \Delta p_t = \beta_0 + \beta_1 \Delta c_t - \beta_2 \Delta i_t + \varepsilon_{1,t} \quad (14)$$

$$\Delta p_t = \alpha_0 + \alpha_1 \Delta p_t^* + \alpha_2 \Delta e_t + \varepsilon_{2,t} \quad (15)$$

$$\frac{\Delta B_t}{B_{t-1}} - \Delta r_t - \Delta y_t^{trend} - \Delta p_t = \gamma_0 + \lambda \Delta r_t + \gamma_1 \Delta p_t + \gamma_2 y_t^{gap} + \varepsilon_{3,t} \quad (16)$$

Equations (14) and (15) are obtained directly from equations (2) and (3). Equation (16) is derived by substitution of (6) into (4) and noting that change in money supply equals the change in money base $\frac{\Delta B_t}{B_{t-1}}$ assuming the money multiplier to be constant.

One can distinguish two types of variables included in the model: endogenous and exogenous. The endogenous variables are Δm_t , Δp_t , Δe_t , Δi_t , $\frac{\Delta B_t}{B_{t-1}}$ and Δr_t . The exogenous variables are Δc_t , Δp_t^*, Δi_t^*, Δy_t^{trend} and Δy_t^{gap} . Despite the fact that Δe_t does not appear on the left-hand side of any of the equations, it is the endogenous variable because the exchange rate is clearly the variable determined by this model.

The model is estimated using the two-stage least square regression technique (2SLS). The main reason is that the endogenous variables are on both sides of equations (2)-(8). It means that in each equation having endogenous variables on the right-hand side, these variables are likely to correlate with the disturbance term. Thus, using the ordinary least square method would lead to biased estimates. Adequacy of using 2SLS for each equation was confirmed by results of Hausman specification test that may be obtained from the author upon request.

The 2SLS used requires the incorporation of instruments (variables uncorrelated with the disturbance term) into the estimation. To find appropriate instruments we run the first stage regressions on endogenous variables having all possible instruments as regressors. As possible instruments we set the contemporaneous and one-quarter lagged values of exogenous variables and one-quarter lagged values of all endogenous variables. Finally, the regressors with sufficient statistical significance were selected as instruments.

We applied Augmented Dickey-Fuller tests to examine the stationarity of the time series used. According to the character of each time series we tested the stationarity with a linear trend and/or intercept or none of them. Tests' results allow us to conclude that the first differences of all time series are stationary. Thus, they can be used in estimation of all equations of the model. The percentage change in money base is a naturally flow variable and, thus, already differenced and stationary. Likewise, y_t^{gap} is stationary on levels in three countries because of its construction. The results of unit root tests are not reported here, they may be provided upon request.

The 2SLS estimation results are presented in Appendix 2, individually for each equation. The tables also contain the list of instruments and results of some diagnostic tests. We applied Jarque-Berra (J-B) indicator to assess normality of the residuals distribution, Breusch-Godfrey Lagrange multiplier (LM) to test serial correlation, Lagrange multiplier test for autoregressive conditional heteroscedasticity (ARCH) and White test to check heteroscedasticity of the error term. All LM and ARCH tests were run with four lags. We also applied Sargan test to evaluate validity of the selected instruments.

The tests indicated evidence of potential heteroscedasticity in some cases. Therefore, we corrected the standard errors of parameter estimates by the Newey-West procedure. Furthermore, the residuals in some equations seem to be non-normally distributed. Therefore, although the t-statistics can be misleading, this does not reduce the validity of the parameter estimates. Since different equation specifications have different instruments, R^2 for 2SLS can be negative even if a constant is used in the equation. According to the model specification the parameters β_1, α_1, and α_2 should be positive and β_2, γ_1, γ_2, and λ should be negative. Since λ is a fraction, its absolute value should be between zero and one.

The estimations of the money demand equation (14) provide mediocre results. Although all coefficients are signed in accordance with expectations only some of them are statistically significant. One can point out that, due to generally higher and more volatile interest rates, the elasticity of money demand with respect to the domestic interest rate (β_2) is considerably higher in Hungary and Poland than in the Czech Republic and Slovakia. The error terms in equation (14) pass the diagnostic tests in three countries. In Hungary, however, there is evidence of non-normal distribution and heteroscedasticity. The instruments in all countries seem to be chosen properly.

Results obtained in estimations of equation (15) are somewhat poor. The signs of all parameters are consistent with theoretical assumptions. However, important α_2 parameters are significantly different from zero only in Hungary. The impact of changes in exchange rates on domestic inflation is insignificant since the exchange rate innovations are accommodated by producers and importers and not fully transmitted into consumer prices. The residuals are normally distributed with no evidence of serial correlation and autoregressive conditional heteroscedasticity. Only error terms in the Czech Republic and Hungary seem to be heteroskedastic. The Sargan tests confirm validity of instruments in all equations estimated.

The results from the money supply equation (16) are not satisfactory either. The important elasticity of the money base with respect to the domestic inflation (γ_1) and the sterilization coefficients (λ) are statistically significant only in the Czech Republic and Slovakia. Other parameters are correctly signed (except for λ in Poland) but insignificant. Neither the performance of the elasticities of the money base with respect to the domestic output (γ_2) are significant. According to Spolander (1999, 72) this problem stems from different specification of the equation and, unfortunately, it is a common drawback of many studies of monetary policy rules and reaction functions.

Using the Wald test we tested the null hypothesis that the sterilization coefficient (λ) equals to minus unity, which implies full sterilization. The null hypothesis can be rejected only in the Czech Republic and Slovakia. However, the EU4 central banks have never publicly declared that all foreign exchange intervention has no impact on the money base. Hence, we assume that the parameter estimates of λ indicate less than full sterilization in all EU4. This assumption is in accordance with the practice of central banks from developed countries which usually sterilize their intervention partially rather than fully. The values of the model-dependent measure of EMP are calculated according to equations (1) and (11). The model-dependent EMP development is graphically presented for all countries in Appendix 3.

Second, we estimate EMP based on the model-independent approach specified in equation (13). Since this alternative EMP calculation requires neither derivation of a structural model nor computation of the conversion factor the estimation process is obvious and any detailed clarification is not necessary. The obtained values of the model-independent EMP are reported in Appendix 3.

To evaluate EMP correctly it is necessary to remember some elementary facts. First, a negative value of EMP indicates that the currency is under general pressure to appreciate. On the contrary, positive EMP shows that the currency is pressured to depreciate. Second, the value of EMP represents the magnitude of the foreign exchange market disequilibrium which should be removed by a respective change of the exchange rate. The graphs in Appendix 3 contain, besides the EMP curve, the lines representing 1.5 multiple of the standard deviation above and below the mean EMP value. A breach of the corridor is considered as an excessive EMP, alerting to a potential crisis. Such a construction of thresholds has been widely adopted in many studies and has become preferred method to e.g. the extreme value theory (see Pontines and Siregar, 2006).

3.2 Comparison of Alternative Estimates

The comparison of the EMP estimates can be done from two perspectives: (i) cross-country comparison, and (ii) comparison of model-dependent and model-independent estimates. The cross-country comparison is motivated by the hypothesis that EU4 countries are often assumed to be relatively homogeneous group of countries at similar stage of the integration process. Thus, a resembling development of EMP, particularly during the last third of the estimation period, would not be surprising.

However, as it is clear from graphs in Appendix 3 one can hardly consider the EMP development in EU4 as homogeneous. Although a few episodes of similar EMP behavior can be observed the most of the period analyzed is characterized by a substantial level of divergence. The national EMP estimates differ not only in magnitude but also in sign and direction of change. Moreover, the heterogeneity of the national EMP development is documented by correlation analysis. As regards to the model-dependent EMP, we revealed the highest correlation coefficient between the Czech EMP and Hungarian EMP (0.4169) and the lowest one between the EMP in the Czech Republic and Slovakia (0.0753). The correlation analysis of the model-independent measures indicates even less uniformity across EU4. The highest coefficient (0.2644) was obtained between EMP in Hungary and Poland and the lowest correlation (in absolute value) was found between the Czech Republic’s and Poland’s EMP (0.0056). Hence, we may conclude that EMP development in EU4 is driven by country-specific factor and the hypothesis about EMP homogeneity in EU4 can be rejected.

In the second kind of comparison we investigate how consistent are the two alternatives of the EMP estimation. Principally, we evaluate how different are the obtained EMP observations and how harmonious are the alternatives in identification of excessive EMP. The elementary descriptive statistics is presented in Table 1.

The only country with results signaling some degree of consistency is the Czech Republic. Means and medians of both EMP indices have negative signs and the standard deviations do not differ significantly. Subsequently, the no-crisis corridors have similar width as well as upper and lower margin.

Poland's EMP results also show some attributes of consistency but the no-crisis band of the model-independent approach is located more in the PLN depreciation zone then it is the case of model-dependent model. The reported results are rather contradictory as they do not allow us to draw any conventional conclusion. None of the approaches yields to considerably more volatile EMP development or wider differentials between maximum and minimum EMP observations. Likewise, none of the approaches tends to identify more cases of excessive EMP.

Table 1

Descriptive statistics of exchange market pressure

	Czech Republic		Hungary		Poland		Slovakia	
	DEP	IND	DEP	IND	DEP	IND	DEP	IND
mean	-0.011	-0.006	-0.006	0.019	-0.027	-0.006	-0.023	-0.005
median	-0.003	-0.007	-0.004	0.016	-0.016	-0.000	-0.013	0.002
max	0.0591	0.1403	0.0319	0.1573	0.0444	0.1229	0.1197	0.0947
min	-0.135	-0.123	-0.078	-0.060	-0.280	-0.200	-0.256	-0.127
st. dev.	0.0343	0.0389	0.0207	0.0446	0.0552	0.0536	0.0629	0.0374
upper	0.0404	0.0522	0.0250	0.0859	0.0554	0.0749	0.0709	0.0511
lower	-0.063	-0.065	-0.037	-0.048	-0.110	-0.086	-0.118	-0.061
excess	3; 1; 2	5; 3; 2	5; 2; 3	5; 3; 2	4; 0; 4	4; 2; 2	5; 2; 3	5; 1; 4

Source: Author's calculations.

Notes: DEP and IND denote model-dependent and model-independent approach respectively. Excess means number of occurrences of excessive EMP (breaches of non-crisis corridor) in the following order: total; positive; negative.

However, if we split the estimation period into two sub-periods with the break point in 2000 we can unfold some hidden findings. Whereas the estimations of the model-dependent approach show substantially higher and more volatile EMP in all countries over the first sub-period the model-independent approach leads to totally opposite conclusions. Using the model-dependent approach we revealed 10 observations of excessive EMP in the first sub-period and only six occurrences in the second one. On the contrary, the model-independent approach detected five and 14 episodes of excessive EMP respectively. The higher number of "crisis" observations obviously contributed to higher EMP volatility. So contradictory EMP development rises the question what makes a difference between the two sub-periods. We should remind that all EU4 made the exchange rate regime more flexible of shifted the arrangement from fixed to floating regime before beginning of the second sub-period. Moreover, a several-years-lasting period of EU4 currencies depreciation against EUR came to the end in 2000.

The diametrical results indicate a lack of consistency between the empirical methods applied. The consistency of the two EMP indices should be assessed more accurately. Table 2 reports correlation coefficients between the model-dependent and model-independent EMP and consistency of both approaches in identification of EMP of same sign and similar magnitude.

Table 2

Consistency of alternative approaches

	Czech Rep	Hungary	Poland	Slovakia
correlation coefficient	0.3080	0.0005	0.0189	0.1605
same sign (%)	50.00	44.23	59.61	41.38
similar magnitude (%)	21.15	13.46	13.46	23.08
crisis	1	0	0	0

Source: Author's calculations

***Notes**: Similar magnitude means that value of the model-dependent EMP is within interval 50%-150% of the model-independent EMP value. Crisis means number of excessive EMP identified by both approaches.*

All the results presented provide evidence of low consistency. The correlation coefficients are low suggesting no linear relationship between the EMP indices. Around half of the EMP estimations are signed reversely and approximately 20 percent of the observations are of similar magnitude. Insufficient degree of consistency is also reflected in ability of the approaches to identify the crisis (excessive EMP) concurrently. The only example of excessive EMP revealed by both approaches occurred in the Czech Republic in the second quarter of 2002. Since there are fundamental differences in results obtained from the alternative estimation approaches we should be cautious when interpreting the EMP development.

3.3 Exchange Market Pressure and Exchange Rate Arrangements

One of the paper's aims is to put EMP estimations in context of exchange rate arrangement and find out whether any relationship exists between these two. Many studies have focused on question how reliable indicator of the exchange rate regime is the de jure classification reported by the International Monetary Fund or announced by national central banks or governments. Most of them (e.g. Levy-Yeyati and Sturzenegger, 2005; or Reinhart and Rogoff, 2004) conclude that serious differences between the reported and practically applied regimes can be found in many countries. Therefore, we construct the following continuous measure of de facto exchange rate arrangement inspired by the methodology used in Levy-Yeyati and Sturzenegger (2005).

$$DFI = \frac{\sigma_{r_t}}{\sigma_{e_t} + \sigma_{\Delta e_t}} \tag{17}$$

where: DFI is de facto regime indicator, σ_{r_t} denotes volatility of reserves, σ_{e_t} is volatility of exchange rate, and $\sigma_{\Delta e_t}$ is volatility of the exchange rate changes. The volatility of reserves is measured as average of absolute changes in the indicator of intervention in the foreign exchange market. The intervention indicator r_t is defined as follows:

$$r_t = \frac{R_t - R_{t-1}}{\frac{Monetary\,Base_{t-1}}{e_{t-1}}} \tag{18}$$

where net reserves R_t are computed according to the following formula:

$$R_t = \frac{Foreign\,Assets_t - Foreign\,Liabilities_t - Central\,Government\,Deposits_t}{e_t}. \tag{19}$$

The volatility of exchange rate is measured as the average of the absolute monthly percentage changes in the nominal exchange rate of the EU4 national currency against the euro. The volatility of the exchange rate changes is calculated as the standard deviation of the monthly changes in the exchange rate. All the data used for calculation of DFI were obtained from the IMF's International Financial Statistics.

DFI is a continuous measure of de facto exchange rate arrangement as it uses a rolling window of 12 last monthly observations. Hence, one can discover how different the exchange rate regimes were over the examination period and how they varied across the countries. However, the purpose of DFI is not to provide an exact judgment on what kind of de facto regime is in action. Instead, we use DFI for identification of changes and trends in the exchange rate policy to recognize, for instance, whether a more fixed regime encourages EMP to increase.

Table 3 reports the economic logic of DFI. The expected level of volatility of each DFI's component is reported according to nature of exchange rate arrangement. Thus, we can derive the key guideline for the interpretation of DFI: the higher DFI the more fixed de facto exchange rate regime. The graphs showing development of DFI along with both EMP estimates are presented in Appendix 4.

Table 3

Interpretation of DFI and its components

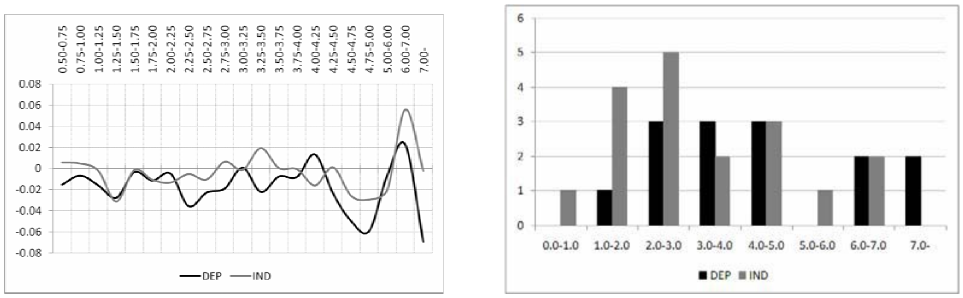
	σ_{r_t}	σ_{e_t}	$\sigma_{\Delta e_t}$	DFI
flexible	low	high	high	lowest
semi-flexible	high	high	high	lower
semi-fixed	high	high	low	higher
fixed	high	low	low	highest

Source: Levy-Yeyati and Sturzenegger (2005, p. 1611).

We merged EMP and DFI observations of all countries into one dataset aiming to uncover any relationship between EMP and de facto exchange rate regimes in EU4. Subsequently, we scaled DFI into 21 intervals while the regular width of the interval is 0.25. Such a width was set in order to get sufficient number of observation for each interval. Due to this reason few intervals on the fixed end of DFI range were extended to 1.00. Finally, we calculated mean value of the model-dependent as well as model-independent EMP for each DFI interval. The averages obtained are reported on left in Figure 1.

Figure 1

Average EMP in relation to de facto regime



Source: Author's calculations.
Note: DEP is the model-dependent EMP and IND is the model-independent EMP.

It is clear that EMP means do not differ substantially across DFI intervals. One can notice only a tendency of the most fixed de facto regime to be teamed up with higher EMP. We also carried out a special analysis of all observations of excessive EMP and computed average DFI for the excessive EMP. While the average DFI of excessive model-dependent EMP is 4.295 the average DFI of model-independent excessive EMP is 3.542.

The right part of Figure 1 depicts number of "crisis" EMP observations identified for extended DFI intervals. The excessive EMP observations are distributed over the intervals quite evenly with no clustering around any specific DFI value. Thus, we may conclude that there is no evidence of serious relationship between EMP and de facto exchange rate regime in EU4. We also tested this conclusion with panel OLS regression. The estimated coefficient of DFI was statistically insignificant in both models (with model-dependent EMP and model-independent EMP as the dependent variable in regression).

On the example of Slovakia we can illustrate how the entry into ERM II may affect EMP and de facto regime. SKK joined ERM II in November 2005 and was operating in this mechanism until the end of 2008. Although Slovakia made a change in de jure arrangement as they replaced a managed floating by a quasi-fixed ERM II, this shift was not reflected in de facto regime. We revealed only one impulsive and short-lasting increase in DFI around the time of ERM II entry. The effect of joining ERM II on EMP was even less evident. Although we rely solely on experience of one country we believe that, knowing other aspects of the EMP development, the entry to ERM II in remaining EU4 would not affect EMP significantly and, thus, would not pose any threat to fulfillment of the exchange rate stability convergence criterion.

Conclusion

In this paper, we estimated EMP for the EU4 currencies against the euro exchange rate over the period from 1995-2008. Fundamental differences in spirit and construction of the approaches applied are reflected in considerably different results.

Thus, the two alternatives are not compatible if the data from EU4 are used. However, we can draw some elementary conclusions. None of EU4 faced a substantial EMP for more than one quarter. HUF was the only currency with prevailing depreciation EMP. While the model-dependent approach yields to higher and more volatile EMP in all countries before 2000 the model-independent approach leads to totally opposite conclusions.

Owing to some factors the EMP estimates presented and discussed previously must be viewed with some degree of skepticisms. Besides already discussed drawbacks, the model-dependent EMP in all countries developed almost concurrently with the changes in reserves over the entire period. It implies a frequent application of the central bank official intervention even in the environment of the floating exchange rate regime. However, the reality in many EU4 was different. In future research we recommend use of the pure foreign exchange intervention data as the alternative to the change in reserves. The model can also be extended by the possibility of indirect intervention operating through changes in the domestic lending or interest rate.

Therefore, for practical purposes and estimation of EMP in EU4 we suggest using of the model-independent approach. It puts greater emphasis on the interest rate differential, which has often been identified as one of the factors of the exchange rate determination in EU4.

The study does not confirm the concerns that the unavoidable shift in the exchange rate regime towards the quasi-fixed ERM II will evoke EMP to grow to excessive levels. Instead, the empirical tests and up to date experience suggest that the de jure regime change will have, with a high probability, a negligible impact on the de facto regime and EMP development. Thus, the entry to ERM II does not a priori mean a threat to fulfillment of the exchange rate stability convergence criterion.

References

Bielecki, S. (2005), "Exchange market pressure and domestic credit evidence from Poland", *The Poznan University of Economics Review*, 5(1): 20-36.

Eichengreen, B.J., Rose, A.K. and Wyplosz, C. (1994), "Speculative Attacks on Pegged Exchange Rates: an Empirical Exploration with Special Reference to the European Monetary System", NBER Working Paper No. 4898.

Eichengreen, B.J., Rose, A.K. and Wyplosz, C. (1995), "Exchange Market Mayhem: The Antecedents and Aftermath of Speculative Attacks", *Economic Policy*, 10(21): 249-312.

Girton, L. and Roper, D.E. (1977), "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience", *American Economic Review*, 67(4): 537-48.

Kaminski, G., Lizondo, S. and Reinhart, C. (1998), "Leading indicators of currency crises", *IMF Staff Papers*, 45(1): 1-48.

Kaminski, G. and Reinhart, C. (1999), "The twin crises: The causes of banking and balance-of-payments problems", *American Economic Review*, 89(3): 473-500.

Levy-Yeyati, E. and Sturzenegger, F. (2005), "Classifying exchange rate regimes: Deeds vs. words", *European Economic Review*, 49(6): 1603-35.

Pentecost, E.J., Van Hoydonk, C. and Van Poeck, A. (2001), "Measuring and Estimating Exchange Market Pressure in the EU", *Journal of International Money and Finance*, 20(3): 401-18.

Pontines, V. and Siregar, R. (2006), "Identifying and Dating the Episodes of Speculative Pressures against the Singapore Dollar", *Singapore Economic Review*, 51(2): 113-33.

Reinhart, C.M and Rogoff, K.S. (2004), "The Modern History of Exchange Rate Arrangements: A Reinterpretation", *The Quarterly Journal of Economics*, 119(1): 1-48.

Roper, D.E. and Turnovsky, S.J. (1980), "Optimal Exchange Market Intervention in a Simple Stochastic Macro Model", *Canadian Journal of Economics*, 13(2): 296-309.

Sachs, J.D., Tornell, A. and Velasco, A. (1996), "Financial crises in emerging markets: The lessons from 1995", *Brooking Papers on Economic Activity*, 1: 147-215.

Spolander, M. (1999), "Measuring Exchange Market Pressure and Central Bank Intervention", Bank of Finland Studies E:17.

Stavárek, D. (2006), "Exchange Market Pressure before Entering the ERM II - The Case of Central European Countries", *Amfiteatru Economic*, 19: 34-9.

Tanner, E. (2002), "Exchange Market Pressure, Currency Crises, and Monetary Policy: Additional Evidence from Emerging Markets", IMF Working Paper WP/02/14.

Turnovsky, S.J. (1985), "Optimal Exchange Market Intervention: Two Alternative Classes of Rules", In: Bhandari, J.S. (ed) *Exchange Rate Management Under Uncertainty*. Cambridge: MIT Press.

Van Poeck, A., Vanneste, J. and Veiner, M. (2007), "Exchange Rate Regimes and Exchange Market Pressure in the New EU Member States", *Journal of Common Market Studies*, 45(2): 459-85.

Weymark, D.N. (1995), "Estimating Exchange Market Pressure and the Degree of Exchange Market Intervention for Canada", *Journal of International Economics,* 39(3-4): 273-95.

Weymark, D.N. (1997a), "Measuring the Degree of Exchange Market Intervention in a Small Open Economy", *Journal of International Money and Finance*, 16(1): 55-79.

Weymark, D.N. (1997b), "Measuring Exchange Market Pressure and Intervention in Interdependent Economy: A Two-Country Model", *Review of International Economics*, 5(1): 72-82.

Weymark, D.N. (1998), "A General Approach to Measuring Exchange Market Pressure", *Oxford Economic Papers*, 50(1): 106-21.

Appendix 1: Data description

B_t	EU4 national money base Obtained from IMF's International Financial Statistics (IFS) line 14 (Reserve money) and then logged.
c_t	EU4 Gross national income Derived by adding the net income from abroad to Gross domestic product (IFS line 99B). In national accounts statistics, the total of rents, interest, profits and dividends plus net current transfers is shown as "net income from abroad". It was obtained from IFS by differencing current account balance (IFS line 78ALD) and balance on goods and services (IFS line 78AFD). Logged values.
e_t	Nominal bilateral exchange rate of EU4 currencies vis-à-vis Euro in direct quotation (number of EU4 currency units for one Euro) Obtained from Eurostat's Economy and finance database (EEF) section Exchange rates and Interest rates, line Euro/ECU exchange rates – Quarterly data. Logged values.
i_t^*	Eurozone 3-month money market interest rate Obtained from EEF section Exchange rates and Interest rates, line Money market interest rates – Quarterly data, series MAT_M03
i_t	EU4 national 3-month money market interest rate Obtained from EEF section Exchange rates and Interest rates, line Money market interest rates – Quarterly data, series MAT_M03
m_t	EU4 national M1 monetary aggregate Obtained from IFS line 34..B (Money, Seasonally Adjusted) and then logged.
p_t^*	Eurozone Harmonized indices of consumer prices Obtained from EEF section Prices, line Harmonized indices of consumer prices – Monthly data (index 2005=100). Converted from monthly to quarterly data by averaging the three monthly figures and then logged.
p_t	EU4 national Harmonized indices of consumer prices Obtained from EEF section Prices, line Harmonized indices of consumer prices – Monthly data (index 2005=100). Converted from monthly to quarterly data by averaging the three monthly figures and then logged.
r_t	EU4 national official reserves holdings Obtained from IFS line 1L.D (Total Reserves Minus Gold) converted to national currency using nominal bilateral exchange rate vis-à-vis US dollar (IFS line AE) and then logged.
rm_t	Proportional change in domestic international reserves Obtained by ratio of change in the level of reserves (IFS line 79DAD) and money base of previous period (IFS line 14).
y_t	EU4 national Gross domestic product Obtained from IFS line 99B (Gross Domestic Product) and then logged.
y_t^{trend}	Long-run component of y_t Obtained using the Hodrick-Prescott filter and a smoothing parameter of 1600, as recommended for quarterly data.

Appendix 2: Estimations of equations (14)-(16)

Equation (14)							
Czech Republic				Hungary			
instruments: Δr_{t-1} Δp^*_{t-1}				instruments: Δc_t Δe_{t-1}			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
β_0	0.0035	0.0013	0.0149	β_0	-0.0066	0.0080	0.4097
β_1	0.1847	0.1647	0.2675	β_1	0.7117	0.5341	0.1890
β_2	-0.0175	0.0082	0.0382	β_2	-0.1768	0.1791	0.3284
R^2=0.0961, SEE=0.0073, DW=2.0768				R^2=-4.7576, SEE=0.0208, DW=1.4587			
J-B=0.7045 (0.7031), LM=0.9699 (0.4336) ARCH=0.9520 (0.4437), WH=1.3766 (0.2622) SARGAN=0.0008 (0.9774)				J-B=7.3480 (0.0253), LM=8.5820 (0.0724) ARCH=2.3254 (0.0720), WH=86.045 (0.0000) SARGAN=0.0005 (0.9821)			
Poland				Slovakia			
instruments: Δi^*_t Δi_{t-1} Δi^*_{t-1}				instruments: Δc_{t-1} Δr_{t-1}			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
β_0	0.0030	0.0033	0.3559	β_0	0.0048	0.0017	0.0101
β_1	0.4808	0.2899	0.1038	β_1	0.1603	0.1732	0.3593
β_2	-0.0547	0.0214	0.0140	β_2	-0.0079	0.0086	0.3637
R^2=-0.3078, SEE=0.0145, DW=2.4524				R^2=0.0200, SEE=0.0126, DW=2.0457			
J-B=0.5631 (0.7546), LM=5.2907 (0.2587) ARCH=0.0607 (0.9929), WH=0.3406 (0.7130) SARGAN=0.4409 (0.5066)				J-B=0.5978 (0.7414), LM=0.9361 (0.4519) ARCH=0.1382 (0.9672), WH=0.0194 (0.9807) SARGAN=0.0001 (0.9920)			
Equation (15)							
Czech Republic				Hungary			
instruments: Δc_{t-1} Δe_{t-1}				instruments: Δy^{trend}_t Δy^{trend}_{t-1} Δe_{t-1}			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
α_0	0.0066	0.0030	0.0328	α_0	-0.0003	0.0059	0.9571
α_1	3.2755	2.5305	0.2017	α_1	3.0139	5.4265	0.5812
α_2	0.4157	0.3645	0.2598	α_2	1.2964	0.2822	0.0000
R^2=-2.3312, SEE=0.0050, DW=1.7723				R^2=-1.0183, SEE=0.0060, DW=1.6505			
J-B=0.1564 (0.9247), LM=1.1282 (0.8898) ARCH=0.9420 (0.4492), WH=13.274 (0.0000) SARGAN=0.0004 (0.9840)				J-B=0.9109 (0.6341), LM=5.9595 (0.2022) ARCH=1.9892 (0.1012), WH=12.855 (0.0000) SARGAN=2.0574 (0.1514)			
Poland				Slovakia			
instruments: Δi_{t-1} Δy^{gap}_t				instruments: Δr_{t-1} Δi_{t-1} Δi^*_t			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
α_0	0.0024	0.0007	0.0035	α_0	0.0042	0.0022	0.0695
α_1	1.2531	0.5792	0.0354	α_1	0.6970	2.2656	0.7597
α_2	0.0116	0.0240	0.6300	α_2	0.0693	0.1933	0.7214
R^2=0.0589, SEE=0.0041, DW=1.6757				R^2=-0.0344, SEE=0.0034, DW=1.9463			
J-B=1.4930 (0.4738), LM=3.6507 (0.1612) ARCH=1.6845 (0.1745), WH=0.4389 (0.6473) SARGAN=0.0000 (0.9999)				J-B=3.5220 (0.1719), LM=7.1797 (0.1267) ARCH=1.7535 (0.1564), WH=0.3439 (0.8834) SARGAN=2.3294 (0.1269)			

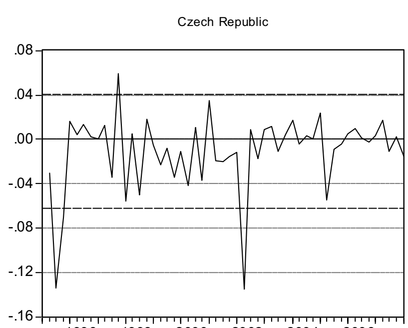
Source: Author's calculations

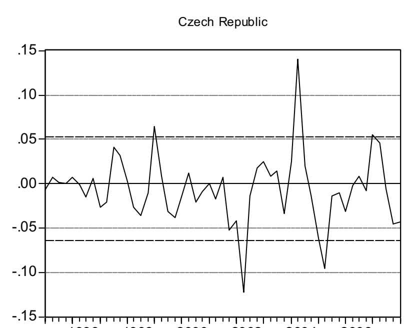
Appendix 2 (continued): Estimations of equations (14)-(16)

Equation (16)							
Czech Republic				Hungary			
instruments: Δc_t Δp_t^* Δp_{t-1}^* Δy_t^{trend} Δe_{t-1} Δy_{t-1}^{gap} Δm_{t-1}				instruments: Δp_t^* Δy_t^{trend} Δy_{t-1}^{trend}			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
γ_0	-0.0006	0.0019	0.7302	γ_0	-0.0017	0.0052	0.7486
λ	-0.5455	0.1278	0.0001	λ	-0.5444	2.1111	0.7976
γ_1	-2.0950	1.1321	0.0705	γ_1	-0.9186	1.2484	0.4655
γ_2	0.0025	0.0014	0.0967	γ_2	-0.0028	0.0039	0.4715
R^2=0.2905, SEE=0.0195, DW=1.8375				R^2=-0.4238, SEE=0.0220, DW=2.5263			
J-B=650.91 (0.0000), LM=3.1093 (0.5397) ARCH=0.1366 (0.9678), WH=1.7935 (0.1613) SARGAN=5.5538 (0.0622)				J-B=77.107 (0.0000), LM=6.2724 (0.1797) ARCH=0.0744 (0.9896), WH=3.7906 (0.7050) SARGAN=0.0002 (0.9999)			
Poland				Slovakia			
instruments: Δi_{t-1} Δm_{t-1} Δp_t^* Δe_{t-1} Δr_{t-1}				instruments: Δc_t Δy_t^{trend} Δy_{t-1}^{trend}			
param.	estim.	st.er.	prob.	param.	estim.	st.er.	prob.
γ_0	-0.0088	0.0113	0.4389	γ_0	0.0023	0.0040	0.5575
λ	0.4541	0.9825	0.6461	λ	-0.7345	0.2032	0.0007
γ_1	-5.0645	4.7172	0.2885	γ_1	-1.4983	0.6234	0.0202
γ_2	-0.0061	0.0044	0.1737	γ_2	-0.0002	0.0001	0.1231
R^2=-1.4955, SEE=0.0426, DW=2.1921				R^2=0.2182, SEE=0.0317, DW=2.6675			
J-B=76.521 (0.0000), LM=3.3569 (0.5000) ARCH=0.0736 (0.9898), WH=3.9895 (0.6780) SARGAN= 0.0093 (0.9953)				J-B=0.6398 (0.7262), LM=0.5676 (0.9666) ARCH=0.4548 (0.7683), WH=13.160 (0.0000) SARGAN=0.0001 (0.9999)			

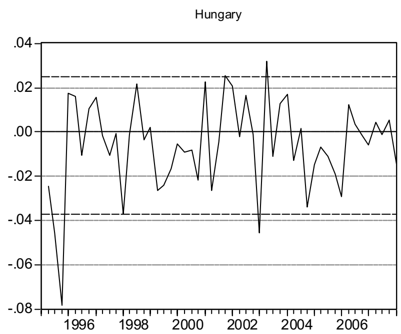
Source: Author's calculations

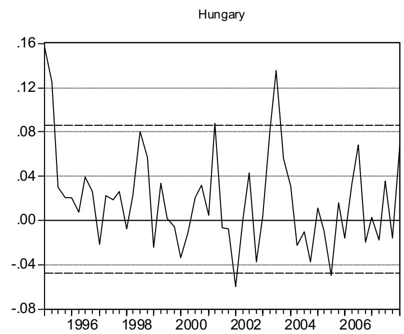
Appendix 3: Model-dependent EMP (left) and model-independent EMP (right)

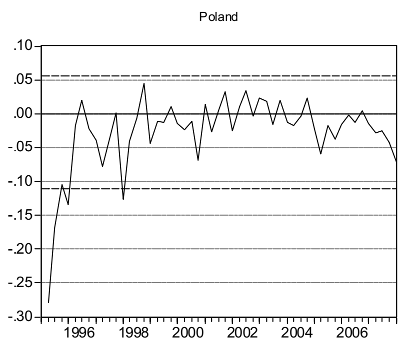


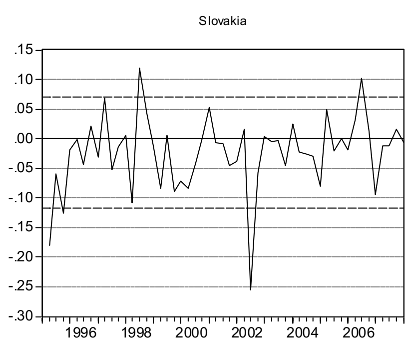


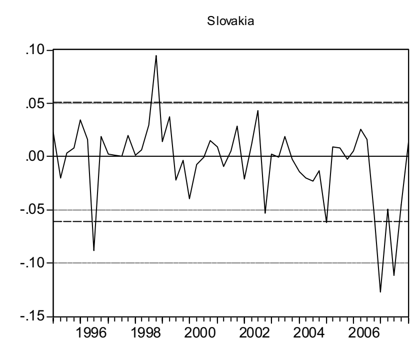
Appendix 3 (continued): Model-dependent EMP (left) and model-independent EMP (right)



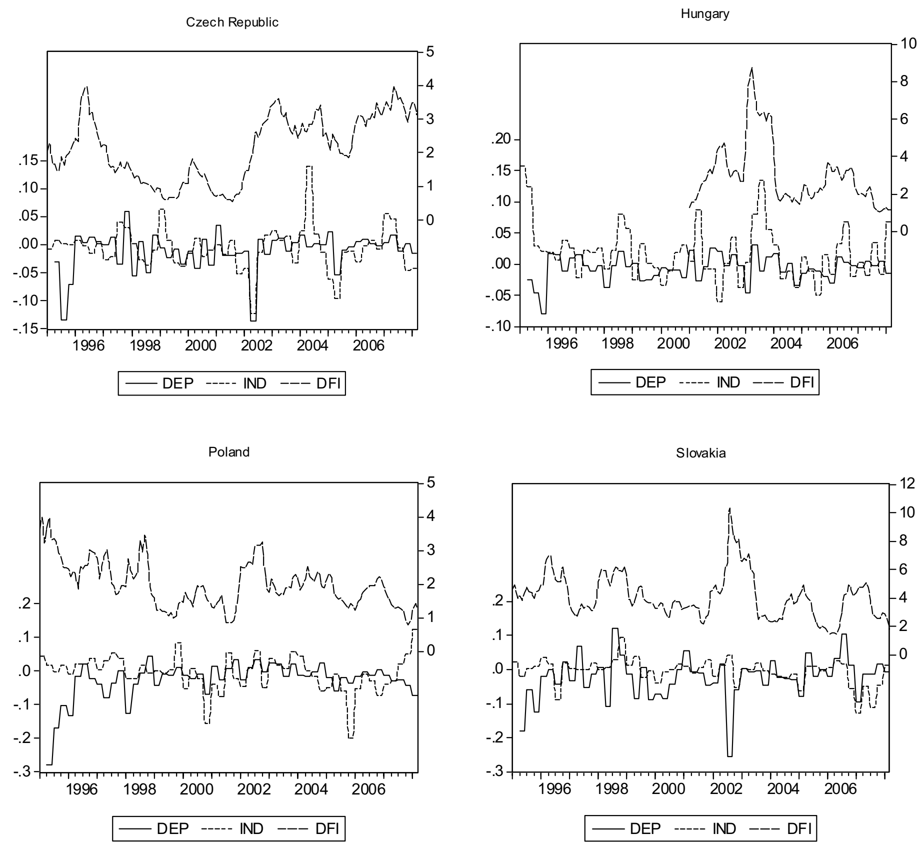








Appendix 4: De facto exchange rate regime (DFI) and exchange market pressure



Source: Author's calculations.

Notes: DEP and IND denote model-dependent and model-independent approach, respectively; DFI is de facto exchange rate regime indicator.