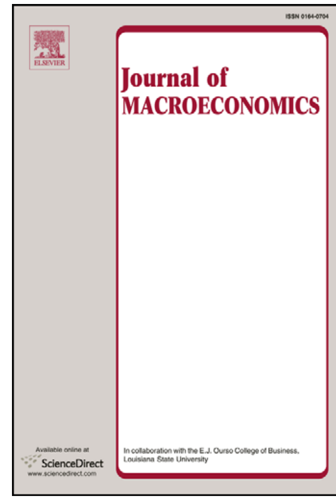
Accepted Manuscript



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Michael Frömmel, Garo Garabedian, Franziska Schobert

PII: S0164-0704(11)00045-0
DOI: 10.1016/j.jmacro.2011.05.003
Reference: JMACRO 2439

To appear in: *Journal of Macroeconomics*

Received Date: 3 February 2010
Accepted Date: 26 May 2011

Please cite this article as: Frömmel, M., Garabedian, G., Schobert, F., Monetary Policy Rules in Central and Eastern European Countries: Does the Exchange Rate Matter?, *Journal of Macroeconomics* (2011), doi: 10.1016/j.jmacro.2011.05.003

Monetary Policy Rules in Central and Eastern European Countries: Does the Exchange Rate Matter?*

Michael Frömmel, Ghent University, Belgium

Garo Garabedian, Ghent University and University College Ghent, Belgium[a]

Franziska Schobert, Deutsche Bundesbank, Germany

May 2011

JEL classification: E52, E58, P20

Keywords: monetary policy, Taylor rules, transition economies, CEEC, inflation targeting

Abstract:

We estimate monetary policy rules for six central and eastern European countries (CEEC) during the period when they prepared for membership to the EU and monetary union. By taking changes in the policy settings explicitly into account and by splitting up the exchange rate impact into two different components we significantly improve estimation results for monetary policy rules in CEEC. We uncover that the focus of the interest rate setting behaviour in the Czech Republic, Hungary and Poland explicitly switched from defending the peg to targeting inflation. For Slovakia, however, there still seemed to be on ongoing focus on the exchange rate. Finally, Slovenia and, after a policy switch, Romania exhibit a solid relation with inflation as well.

*Any findings, interpretations, and conclusions are those of the authors and do not necessarily represent the views of the Deutsche Bundesbank. For helpful suggestions we would like to thank Hans Dewachter, Gerdie Everaert, Evan Kraft, Koen Inghelbrecht, Robinson Kruse, Helmut Lütkepohl, Yves Robson, Robert Tamura, an anonymous referee, and conference and seminar participants at the WHU – Otto Beisheim School of Management (Germany), the Louvain School of Management (Belgium), the Croatian National Bank, and the Annual Congress of European Economic Association, Glasgow (Scotland). The paper benefits from Nils Gottfries' comments on an earlier version.

[a] Corresponding author: Department of Finance, Ghent University/University College Ghent, Voskenslaan 270, 9000 Ghent, Belgium; email address: garo.garabedian@UGent.be

Monetary Policy Rules in Central and Eastern European Countries: Does the Exchange Rate Matter?

1. Introduction

Monetary policy in Central and Eastern European Countries (CEEC) has drawn increasing attention from academics and practitioners. While preparing for membership to the EU and monetary union, the central banks in CEEC were challenged by high inflation in the earlier periods, and then managed to disinflate fairly successfully. The way this was achieved, however, was considerably different: The Czech Republic, Hungary, Poland and Slovakia focused on exchange rate targeting during the first years, but then gradually made their exchange rate system more flexible and adopted inflation targeting as their monetary policy strategy. Romania and Slovenia never officially had a fixed exchange rate regime. While Romania adopted inflation targeting only in August 2005, Slovenia officially followed a monetary targeting strategy for most of the time before adopting a two-pillar-like strategy in the run-up to monetary union (for the official exchange rate and monetary policy regimes see Table 1 and 2).

For these six countries, the interest rate setting behaviour of a central bank can provide important insights into the objectives which are most important in its conduct of monetary policy. A standard approach is to estimate a Taylor-like interest rate reaction function. While the empirical literature concludes that the monetary policy by most successful central banks in large industrial countries can be described by such a reaction function (Clarida et al. 1998), evidence for emerging economies and particularly transition economies is poor.

Regime shifts, however, seem to matter. Kahn and Parrish (1998), for example, find that significant structural breaks in the monetary policy reaction function occurred, after New Zealand and the UK introduced inflation targeting. In both countries the significance of the exchange rate lost importance. Neumann and von Hagen (2002) disclose the same result for a larger country set. Assenmacher-Wesche (2006) estimates reaction functions with time-varying coefficients for Germany, the United Kingdom and the US. These empirical results stress the importance of taking policy changes into account.

Since CEEC are small open economies, one may argue that besides regime shifts also the exchange rate plays a major role in the reaction function. Ball (1999) argues that pure inflation targeting without explicit attention to the exchange rate is dangerous in an open economy, because it creates large fluctuations in exchange rates and output. In this context, the effects of exchange rates on inflation through import prices is the fastest channel from monetary policy to inflation, therefore monetary policy cannot neglect it. The need for considering the exchange rate will be obvious, if the monetary authorities explicitly target the exchange rate, as they (initially) did in many CEEC. However, the way the exchange rate enters the reaction function should then be different, because monetary policy has to react on potential violations of the exchange rate band in order to keep it credible. Thus the reaction is non-linear, as it will get stronger, the closer the exchange rate approaches the intervention margins. It will also be non-discretionary, because the authorities are obliged to react, as long as they intent to sustain the peg.

In line with e.g. Peersman and Smets (1999), our emphasis is on positive or descriptive rather than normative aspects of policy analysis. We investigate the role of the exchange rate by looking at the interest rate setting behaviour of the central bank and to which degree it has taken exchange rate developments into account. The paper thereby sheds some light on the discussion to which extent the interest setting behavior of these central banks complies with the “fear of floating” hypothesis, as analyzed by Calvo and Reinhart (2002). A central bank that changes interest rates systematically in response to inflation and also to exchange rate shocks is more likely to support evidence on this hypothesis, keeping in mind that the central bank nevertheless still may use interventions in the foreign exchange market as an instrument to steer the exchange rate.

This paper adds to the literature in five ways: First, our analysis covers a longer sample period than most previous studies. We consider a substantial part of the transition period from January 1994 till August 2008. Second, whereas most works only include the Czech Republic, Hungary, Poland and sometimes Slovakia, we add Slovenia and Romania to the sample. Thus we consider all new EU member states in CEEC which one may assume to have pursued a more or less independent monetary policy during a considerable period of time[1]. Third, the analysis takes explicitly into account shifts in exchange rate and monetary policy regimes that have occurred in all the countries of the sample. Fourth, we introduce a non-linear measure of distance to the intervention margins to identify those interest rate changes that stem from the peg. To our knowledge we are the first taking this effect into account. Fifth, we apply the

[1] This is not the case for the remaining CEEC that joined EU: The Baltic states and Bulgaria followed very strict exchange rate regimes and partially currency boards. This means they could not pursue an independent monetary policy.

cointegration methodology to interest rate rules as suggested by Gerlach-Kristen (2003), which has rarely been applied to transition economies. These innovations allow us to retrieve more realistic coefficients from our reaction function, and thus our model better describes the interest rate setting behaviour of the monetary authorities.

The paper proceeds as follows: The following section 2 reviews the research on interest rate rules in transition economies. Section 3 introduces our empirical approach and our distance measure. Section 4 describes the data and presents the empirical results, while section 5 summarizes and concludes.

2. Monetary policy rules in CEEC

Research on monetary policy rules in the context of emerging market economies and particularly transition economies is of more recent origin and relatively scarce. An important finding of Mohanty and Klau (2004) is that central banks in emerging market economies tend to look beyond inflation and focus on other objectives as well, most prominently on exchange rate changes.

The amount of literature specifically on monetary policy rules in CEEC is limited, first because time series available are comparatively short. They usually start in the middle of the 1990s. Second, most CEEC have not followed one single strategy of monetary policy and also gradually made their exchange rates more flexible (see Tables 1 and 2). Third, it is not quite clear which target values for inflation the CEEC followed, as most countries introduced inflation targeting and explicit inflation goals only between 1997 and 2001.

Recently, there have been some attempts to describe the monetary policy in selected CEEC using interest rate rules. Maria-Dolores (2005) and Paez-Farell (2007), for example, estimate Taylor rules for the Czech Republic, Hungary, Poland and Slovakia. The latter finds that there is a reaction to exchange rate movements. Angeloni et al. (2007) set up interest rate rules for the Czech Republic, Hungary and Poland, introducing the US dollar interest rate as a proxy for inflationary pressures of global origin. Yilmazkuday (2008) and Jakab and Vilagi (2008) consider structural breaks in their estimates of monetary policy rules for CEECs. Moons and Van Poeck (2008) find that the accession countries do not differ substantially from the current EMU members with respect to the interest rate setting behavior, and that there has been increased convergence. Remo and Vasicek (2009) apply a DSGE model to Czech data and conclude that the focus of the Czech National Bank was mainly on inflation.

Finally, Horváth (2009) analyzes the policy neutral rate in the Czech Republic. The results indicate a substantial interest rate convergence to levels comparable to the euro area.

Empirical research suggests that a Taylor-like rule is helpful in understanding monetary policy of the CEEC. However, in most cases inflation coefficients are found to be far below unity, thus violating the so-called Taylor principle. If the Taylor principle holds, the policy rate should move more than proportional with increases in the inflation rate and thereby raise the real interest rate. If the monetary policy rule violates the Taylor principle, it will mean that the central bank does not react adequately on bringing down inflation. This result is counterintuitive, as the CEEC have experienced a remarkable degree of disinflation during the last 15 years. The literature suggests mainly two explanations: Angeloni et al. (2007) argue that part of the reaction on inflation is captured by the coefficient on the US interest rate included in their equation. An increase in global inflation would then lead to a composed reaction, which is partly due to domestic inflation via the conventional inflation coefficient and partly due to foreign inflation via the coefficient on the foreign interest rate. One might similarly argue that the exchange rate included in the interest rate rule partially takes the reaction on inflation, as it anchors expectations on future monetary policy. Another argument, proposed by Golinelli and Rovelli (2005) is that the reaction to an increase in inflation may be modest, if the initial interest rate compared to inflation was set high enough. Thus a smaller coefficient means that in the course of the disinflation process monetary policy is getting even more aggressive. The scenario seems to be well applicable to the CEEC. However, one would at least expect the inflation coefficient *to be close to unity* during periods of autonomous monetary policy.

Besides the above mentioned empirical research, the treatment of exchange rate changes in monetary policy rules is also discussed in the theoretical literature. Svensson (2000) compares strict inflation targeting, which implies a vigorous use of the direct exchange rate channel for stabilizing (CPI-) inflation at a short horizon, with flexible inflation targeting, which stabilizes inflation at a longer horizon, and thereby also stabilizes real exchange rates and other variables to a significant extent. The reaction function under inflation targeting in an open economy thus responds to more information, notably to foreign disturbances. The particular importance of the exchange rate for monetary policy rules in the case of emerging economies is also stressed by Amato and Gerlach (2002).

Taylor (2001) argues that a monetary policy rule that reacts directly to the exchange rate, as well as to inflation and output, sometimes performs worse than policy rules that do not react directly to the exchange rate and thereby avoid more erratic fluctuations in the interest rate. In Taylor (2002), however, he points out that monetary policy in open economies is different from that in closed economies. Open-economy policymakers seem averse to considerable variability in the exchange rate. In his view, they should target a measure of inflation that filters out the transitory effects of exchange rate fluctuations, and they should also include the exchange rate in their policy reaction functions.

3. Methodology

Following Taylor's (1993) seminal paper, it has become common to describe monetary policy by a linear feedback rule linking the interest rate to the output and inflation gap.

$$i_t = r^* + \pi_t + \alpha\pi_t^* + \beta y_t^* \quad (1)$$

where i is the short-term nominal interest rate set by the central bank, r* the assumed equilibrium real interest rate, π the actual rate of inflation, π_t* the deviation of the actual inflation rate from the (central bank's) target rate and y_t* the percent deviation of real GDP from its target, the output gap. The condition α>1, known as the Taylor principle, implies that the nominal interest rate is raised by more than one percentage point in response to an increase in inflation of one percentage point in order to increase real interest rates.

In line with Taylor (2002), we apply a monetary policy rule for open economies, which takes into account the role of the exchange rate. We extend this approach and model the exchange rate component with two variables: Δs_t representing the growth rate of the exchange rate for the whole sample period, and b_t, reflecting the exchange rates' position in the band, if the currency is pegged to an anchor currency.

$$i_t = r^* + \pi_t + \alpha\pi_t^* + \beta y_t^* + \delta\Delta s_t + \gamma b_t \quad (2)$$

To model the impact of the exchange rate we thus use two different tools. For countries without explicit exchange rate targets, the growth rate of monthly exchange rates to the euro (before 1999: to the D-mark) is a proxy for the central banks desire to smooth exchange rate fluctuations.[2]

[2] We also included real and nominal effective exchange rates, this does, however, not substantially change the results. Using the exchange rates in levels (instead of growth rates) rather worsens the results.

For the countries with an explicit exchange rate target during the first subperiod, we also incorporate the band distance at which the market rates are located from either band edge.[3] This measure reflects pressure on the exchange rate, as every time the market rate approaches, or actually exceeds, one of the borders the central bank is obliged to react by interventions and/or interest rate changes[4]. Since one would expect a non-linear reaction – the closer the exchange rate approaches the intervention margins the stronger the central bank should react – we do not calculate the distance between the exchange rate and the closer edge, but transform the distance by an exponential function. As long as the exchange rate is inside the band (and far away from the edges) b_t will be close to zero. However, b_t grows exponentially as the market rate approaches the borders and even explodes when it has left the band. Moreover, the measure is signed, since the impact on the central bank's interest rate policy is asymmetric. Thus, our band distance measure is:

$$b_t = \begin{cases} \exp(l_t - s_t), \\ \end{cases}$$

$$b_t = \begin{cases} \exp(l_t - s_t) & \text{if} \quad |l_t - s_t| \leq |s_t - u_t| \\ -\exp(s_t - u_t) & \text{if} \quad |l_t - s_t| > |s_t - u_t| \end{cases} \qquad (3)$$

with l_t the lower boundary of the band (the strong edge), u_t the upper boundary of the band (the weak edge) and s_t the exchange rate. The boundaries used for the calculation are the official bands set by the monetary authorities. In Figures 1-4, we show the evolution of the band distance variable over time, respectively for all the countries in our sample with a pegged exchange rate. Two interesting features stand out. First, the exchange rates often have had appreciating pressure and therefore, were close to the strong edge of the narrow bands. Second, the values increase dramatically during times of crises, when boundaries are reached or exceeded.

Our band distance measure is closely related to the target zone models based on Krugman (1991). These models, such as described in Bartolini and Prati (1999), Crespo-Cuaresma et al. (2005) or Fidrmuc and Horvath (2008), assume that monetary authorities do not intervene as long as the exchange rate is close to the central parity, but take policy actions

[3] The correlation between Δs_t and b_t turns out to be low and insignificant.

[4] It is not unusual to add variables to capture certain pressures on the macroeconomic framework that could affect the parameters. For example, Cecchetti and Li (2008) add a measure of stress in the banking system to the original Taylor equation, which is quite close to our band distance variable. The rationale behind our band distance measure is thus similar, since it measures pressure emerging from the pegged exchange rate.

when it is about to leave the band. However, while Krugman's target zone model describes the behaviour of the exchange rate, we focus on the policy actions themselves.

We expect that monetary policy in CEEC should exhibit different coefficients over time, reflecting the evolution of exchange rate and monetary policy regimes: The initially tight exchange rate pegs should be reflected by a focus on the band distance, combined with a limited ability to directly target inflation. Schnabl (2008) demonstrates a strong link between exchange rate stability and growth rates for the CEEC during this episode, thus motivating policy actions beyond direct interventions on the exchange rate market. However, this initial setting should change when the pegs are abolished and the central banks divert their attention more on inflation. Nevertheless, some monitoring of the exchange rate may remain, which should be reflected by the smoothing element. The weight for output depends on the nature of the shocks and the room that the inflation target policy has left for any output goals.

In our analysis we do not include the lagged interest rate as a smoothing component. Traditional explanations for smoothing interest rate changes include, for example, fear of disrupting capital markets, loss of credibility from sudden large policy reversals or the need for consensus building to support a policy change (Clarida et al., 1998). As this approach may rather entail an econometric solution in order to get meaningful results in an environment which suffers gravely from autocorrelation, we find it more appealing to confront these problems directly, in a generalized least squares framework. According to Rudebush (2002), the increase in predictability by adding lagged interest rates may indicate inconsistency between the rule and the data.

Whereas the variables in the monetary policy rules are often treated as stationary, we follow Gerlach-Kristen (2003) and apply the cointegration methodology. Phillips (1986) claims that, if the variables are (nearly) integrated of order one, static regressions in levels are likely to produce spurious results. In this respect Rudebusch (2002) shows that such static regressions display an R-squared far larger than the Durbin Watson statistic, which may hint at a spurious regression. Therefore, results from monetary policy rules in levels are often regarded as doubtful (Carare et al. 2005). Gerlach-Kristen (2003) states that while interest rates, inflation gap and output gap are likely to be stationary in large samples, in order to draw correct statistical inference it is desirable to treat them as non stationary in relative short samples[5].

[5] See also empirical work: Crespo Cuaresma et al. (2005) estimate a monetary model of the exchange rate for the same six CEEC as in our study from 1994-2002 using cointegration In the same way Fidrmuc (2009)

We apply various unit root tests (Said and Dickey 1984, Kwiatkowski et al. 1992 and Perron 1989) to the data. The latter is less sensitive to structural breaks. The results suggest that interest and inflation rates are integrated of order one, whereas the output gap, the exchange rate growth and the band distance can be treated as stationary. However, any results should be carefully interpreted, taking into account that the sample size is small.

For the cointegration analysis we include all variables, even the stationary ones. This has become common practice in the recent empirical literature (see e.g. Enders 2004, Asteriou and Hall 2007)[6]. We use the bounds testing approach by Pesaran et al. (2001) which explicitly allows for a mix of I(1) and I(0) variables as standard statistical inference based on conventional cointegration tests is no longer valid. First, the optimal lag length (p) is selected through the Akaike and Schwarz' Bayesian information criteria. Because of the weight on the hypothesis of serially uncorrelated error terms for the legitimacy of the test, we set the p-value cautiously[7]. Next, we examine the null hypothesis of no cointegration using an F-statistic for the joint significance of the lagged level coefficients in the next equation (where c_0 and c_{1t} represent drift and trend elements and ξ is assumed to be white noise):

$$\Delta i_t = c_0 + c_1 t + \sum_{i=1}^{P-1} \alpha_i \Delta i_{t-i} + \sum_{i=0}^{P-1} \beta_i \Delta \pi_{t-i} + \sum_{i=0}^{P-1} \chi_i \Delta y_{t-i} + \sum_{i=0}^{P-1} \delta_i \Delta s_{t-i} + \sum_{i=0}^{P-1} \varepsilon_i \Delta b_{t-i}$$
$$+ \gamma_1 i_{t-1} + \gamma_2 \pi_{t-1} + \gamma_3 y_{t-1} + \gamma_4 s_{t-1} + \gamma_5 b_{t-1} + \xi_t$$

If the F-value exceeds the upper bound this indicates the existence of a long run relation. However, if the F-value is smaller than the lower bound, we can not reject the null of no cointegration. Finally, a test statistic in between both critical values would leave us inconclusive (De Vita et al, 2004). Table 3 unravels the values of the bounds test and we retrieve a cointegration relation for all the countries in our sample[8].

In line with Gerlach-Kristen (2003), we do not estimate the full error-correction model, but instead focus on the single-equation approach discussed by Hamilton (1994).

Even though cointegration yields results that are superconsistent, in small samples there may still occur a potential endogeneity bias. Hamilton postulates we can correct for this by

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demonstrates for the same CEEC from 1994-2003 that money demand and all related variables are non-stationary and thus again applies cointegration techniques. This is however less common for Taylor rules.

[6] Lütkepohl (2004, p89) states: "Occasionally it is convenient to consider systems with both I(1) and I(0) variables. Thereby the concept of cointegration is extended by calling any linear combination that is I(0) a cointegration relation, although this terminology is not in the spirit of the original definition."

[7] When both criteria diverge, we retain the highest lag order.

[8] We also apply the instrumental variable cointegration test by Enders et al. (2008), which is not only robust for stationary variables but also allows for dummy variables. This procedure confirms our results.

including past and future changes of the included variables. We get the following form of the Taylor rule (where we also include the disturbance term η_t):

$$i_t = c + \alpha\pi_t^* + \beta y_t^* + \delta\Delta s_t + \gamma b_t + \sum_{k=-1}^{1}(\alpha_{\pi k}\Delta\pi_{t+k} + \beta_{yk}\Delta y_{t+k} + \delta_{sk}\Delta^2 s_{t+k} + \gamma_{bk}\Delta b_{t+k}) + \eta_t \quad (4)$$

As the differences included in equation (4) only serve as a correction, we refer to the most important first part of the regression in what follows[9]. This analysis, similar to a dynamic OLS technique, is attributed to the seminal work of Stock and Watson (1993).

Estimating equation (4) for the whole sample period is, however, meaningless, since the monetary policy rule is likely to substantially differ across subperiods. We therefore introduce dummy variables and allow for the coefficients to shift after the structural breaks, so that we can differentiate between the fixed and the flexible period. We also build in a dummy variable to catch any changes in the intercept. In this sense, the outer framework remains the same and the comparability between periods improves. The above tests for cointegration show that it is justified to use such a combined framework, because even though the parameters may have shifted over time, the variables involved still show a meaningful relation in the long run. This fragmentation of our sample in two separate periods gives us additional insight in the 'fear of floating hypotheses' (Calvo and Reinhart, 2002).

The regime switches are defined as the dates when a narrow exchange rate band is widened to ±15% or completely abolished, according to the official exchange rate regime.[10] We regard a ±15% band as wide enough in order not to prevent a central bank from performing an autonomous monetary policy. This is in line with the observation that some of the countries (namely Hungary) announced inflation targeting in combination with such wide bands. The choice is also supported by the empirical observation that the band distance turns out to be close to zero for the periods with a ±15% band (see Figure 2).

We thus determine the date of the regime switches by focusing on the exchange rate regime as given in table 2, instead of the monetary policy changes as given in table 1[11]. This

[9] For achieving a unified framework and in line with Gerlach-Kristen (2003) we set the number of leads and lags of these elements to one.
[10] We retrieve the following dates: For the Czech Republic we find 27/05/1997 (managed float), Hungary 1/05/2001 (±15% band), Poland 25/03/1999 (±15% band) and Slovakia 1/10/1998 (managed float).
[11] For example, Poland moved over from exchange rate targeting to inflation targeting in 1998, but only moved to a fifteen percent peg from March 1999 onwards. Nonetheless, our focus remains on the second date as the peg implies central bank intervention when the exchange rate violates one of its bands. Even though the focus of monetary policy seems to have switched to inflation, its hands may still be tied if it does not alter the peg. The same comment can be made for Slovakia. Although in both cases (we can conclude from our band distance variable that) the exchange rate troubles dwindled after the announcements of the new monetary policy.

is motivated by the crucial role the exchange rate arrangements played during the first part of the transition period.

As Slovenia and Romania never announced any official fixed exchange rate arrangement we use the findings by Frömmel and Schobert (2006) and set the shift date for *Romania* to 31/12/1998. For *Slovenia,* we highlight a regime shift from implicit crawling band exchange rate regime before ERM2 membership to an explicit horizontal band. Due to the wide margins of the ERM2 we regard it as a shift to an (almost) floating exchange rate regime.

Since we only distinguish between fixed and flexible exchange rates and since the de facto regime switches might differ from the official ones, we tested several alternative break points around our fixed date (but also on the basis of dates retrieved through the Quandt-Andrews breakpoint test, which also lay in the vicinity of our previous date) and we can state that our framework remains largely robust to the modifications.[12]

Through the above discussed changes, equation (4) evolves to

$$i_t = c + \psi d_t + \alpha_1 \pi^*_{1t} + \alpha_2 \pi^*_{2t} + \beta_1 y^*_{1t} + \beta_2 y^*_{2t} + \delta_1 \Delta s_{1t} + \delta_2 \Delta s_{2t} + \gamma b_t \qquad (5)$$

$$+ \sum_{k=-1}^{1} (\alpha_{\pi k} \Delta \pi_{t+k} + \beta_{yk} \Delta y_{t+k} + \delta_{sk} \Delta^2 s_{t+k} + \gamma_{bk} \Delta b_{t+k}) + \eta_t$$

where ψ_i is the dummy for the period i, with i=1 being the fixed exchange rate period, and i=2 the period with flexible exchange rate arrangement and (for most countries) inflation targeting.

Finally, we use a GLS approach[13] to correct the standards errors for autocorrelation and apply a White correction for heteroskedasticity (MacKinnon and White, 1985).

4. Data and Estimation Results

We analyze monthly data for the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia that covers the period between January 1994 and August 2008, thus leaving out the current financial crisis that may distort our results. Our sample includes data from the

[12] The results for these alternative dates and specifications can be retrieved from the authors

[13] We prefer the method described in Johnston and Dinardo (1997), because it gives the possibility to set up a full GLS model, so we do not lose any observations compared to simply transforming the variables. Deeper analysis of the (partial) autocorrelation function of the residuals points towards a AR(1) structure. Besides the dynamic full GLS we also applied a simple OLS version and a transformed GLS estimation. The results, however, do not substantially differ. They are available from the authors on request.

IMF's "International Financial Statistics" database, the OECD's "statistical compendium", and various central banks.

For the interest rate we either implement the three month interbank rate or other money market rates depending on availability[14].

The inflation rate is calculated as the annual rate of change in the consumer price. Considering the inflation gap, one has to keep in mind that all of the investigated countries are involved in a European integration process. These countries thus have to apply a twin inflation target. They do not only face an internal target, which is set by the domestic central bank, but they also have to comply with an external target which is embedded in the Maastricht criteria. In many publications and statements of the CEECs' central banks a distinct focus on the inflation differential to EU countries can be observed. This strengthens our beliefs that the main attention should be on the inflation gap based on the Maastricht criterion. On a more empirical level this intuition is supported by Siklos (2006), with the external European target yielding more consistent results than its internal equivalent. Furthermore, there are several advantages in using the external criterion. First, not all of the countries adopted an inflation target for the whole period, thus there is only limited availability of internal inflation targets. Second, due to several reasons, e.g. the initially limited reputation of central banks or frequent changes in administered prices in CEEC or other shocks outside the control of the central bank, the official targets might substantially differ from the actual target or had to be adjusted over time. The Maastricht target, however, can be regarded as a medium to long-term objective, and therefore seems to be a more reasonable benchmark for inflation.

The output gap is calculated based on industrial production using a Hodrick-Prescott filter (smoothing parameter 14400). The computation of the rate of potential output presents a difficult task (the same applies to the natural rate of unemployment). The results strongly depend on the way it has been conceived. If one assumes the original series to exhibit a deterministic trend, a filter is the most appropriate solution, while a stochastic trend demands differentiation of the variable. We follow the classical Taylor rule analysis and calculate the output gap based on a filter[15]. Although one may expect to retrieve better results using real-

[14] More precisely, we incorporate the three months interbank rate for the Czech Republic, Hungary, Poland and Slovakia and the money market rate for Romania and Slovenia. As a robustness check, we also include various other short term interest rates in our analysis without any substantial change in the results.

[15] In contrast some authors prefer to work with growth rates, although this may lead to over-differentiating (Siklos and Wohar 2005). We also estimated the model with growth rates. This does not affect the estimation output. The results are available from the authors on request.

time data (Orphanides 2001) this is not possible for our sample of countries, as internal estimates are either not available at all or not publicly available.[16]

As a benchmark model, we first estimate equation (4) as a simple open economy framework with fixed parameters over time that serves as a benchmark model. The results are reported in the first column of each country-specific segment of Table 4[17]. However, the interpretation demands caution as the coefficients will potentially be distorted and inconsistent due to the neglected structural break and the time-invariant coefficients. The long term reaction of the interest rate on inflation is above unity only for the Czech Republic and Slovenia, and at least not significantly different from 1 for Hungary. So broadly speaking, we can say that three countries satisfy the Taylor principle.[18] The coefficient for output seems less convincing as only Slovenia has a significant, but counterintuitive sign. The minor role for output in the CEEC's monetary policy also corroborates with e.g. Vonnák (2007) and Jakab et al. (2006) who state that (Hungarian) monetary policy has a rather limited effect on output.

The same applies for the exchange rate growth element, which solely gives meaningful results for the Czech Republic. The parameter which seems significant over all the (fixed exchange rate) countries is the band distance coefficient (although for the Czech Republic this holds for a higher level of significance). This preliminary setting already depicts a relatively realistic picture of the monetary policy stance.[19] Only the equation for Slovakia does not seem to be quite stable.

As a second step, we add the dummy intercept and slice up the variables to mimic both periods more truthfully, thus estimating equation (5). The results are reported in the second column of each country-specific section in Table 4. It is interesting to portrait the regime dependence in the components and intercept dummies and their overall impact (this applies for all countries except Slovenia, where the shift reflects a different episode).

There is a substantial change in the sliced up coefficients. These differences are most obvious for the inflation coefficient. The number of countries satisfying the Taylor principle rises remarkably in the second period (inflation targeting and flexible exchange rate). This pattern corresponds to our expectations that the central banks had more flexibility to monitor

[16] We also tested various specifications based on unemployment rates (both with HP-filter and MA-gap). This did, however, not affect the results. The estimation output is available form the authors.
[17] The constants are not reported as they are not easily interpretable in the cointegration based version of the Taylor rule and serve as an "auxiliary variable" (Gerlach-Kristen, 2003).
[18] However, the coefficient is uniformly smaller than 1.5, which is often taken as a benchmark measure.
[19] The Durbin-Watson statistic and the Breusch-Godfrey (BG) test indicate that the residuals do not show remaining autocorelation.

the inflation target during the second period. Moreover, the band distance element seems quite robust for the new specification and is unambiguously significant for the Czech Republic, Hungary, Poland and Slovakia during their fixed exchange rate regimes. In contrast, the exchange rate changes Δs_t are not significant for all countries but Slovakia. Thus, central banks used the interest rate instrument in order to keep the exchange rate well inside officially announced bands, but they hardly used this instrument in order to smooth exchange rate fluctuations. These relatively high coefficients for inflation during the flexible period also are in contrast with past studies on the same or similar countries, which find insignificant or low values for inflation. This is in line with the argument by Angeloni et al. (2008) that in a Taylor rule the reaction to inflation is partially captured by other variables, in our case the band distance.

Similarly, there are some alternations over time for the coefficients of the output gap and the exchange rate growth. But the importance of these particular elements generally seems to be quite low over both periods.

As an intermediate summary, we can conclude that the interest rate setting behaviour of the respective central banks only paid attention to the exchange rate during periods of officially fixed regimes. This consideration of the exchange rate is best embodied through the band distance. During periods of officially floating exchange rates, central banks increasingly took a more inflation minded approach. Slovakia is an exception as the coefficient on exchange rate growth is significant during its more flexible exchange rate regime. On a more empirical level, we can also state that the new specification raises the explanatory power for all the countries: The adjusted R-squared is comparable to specifications including the lagged interest rate. Therefore we can assume that our specification gives a more realistic fit of the monetary policy rules for these transition countries.

We add alternative specifications to the equations in order to include country-specific features, and in order to conduct some robustness checks. These results are listed in table 5.

For the *Czech Republic* we build in an extra crisis dummy for the turbulent period in June1997. The results show that both inflation coefficients become significant, and there is still a substantial rise. Moreover, the second period's exchange rate component is now correctly signed. Finally, the band distance element remains robust and for the output values there is little change. All of these changes cause a higher adjusted R-squared, suggesting that this may be a more accurate description.

Since in the case of Hungary and Poland the introduction of inflation targeting and the abolishment of the peg did not coincide, these countries require additional considerations. We test a different break date (based on the Andrews-Quandt test) for *Hungary*. The intuition behind this is that we now set the date endogenously through our data instead of imposing it externally[20]. The new break date becomes June 1999, which is comparatively earlier than the official date. Furthermore, we see a more distinct change in the inflation parameters, although they both remain significantly indifferent from unity.

For *Poland* we estimate an alternative specification to assert what happens if we let our observations for the band distance run through for a longer period (than the officially stated pegged period which ends in April 2000) as we have indications that the monitoring of the peg went on a bit longer. Remarkably, the band distance coefficient seems robust and remains significant.

Romania never explicitly announced an exchange rate policy, so no official break date is available. Nevertheless, there are good reasons to assume that a break occurred in December of 1998. The inflation coefficient increases for the later period.[21]

For *Slovakia* the estimation results improve with the specification allowing for the structural break, however, they remain comparatively unstable. Although the band distance element satisfies our expectations, we can not find any realistic inflation coefficients and the adjusted R-squared is relatively low. The specification may therefore be unfit to realistically model the Slovakian data. When we add a band distance element specific for the ERM2 period to the regression, this variable is almost zero (reflected by the insignificant coefficient for γ_{2B} in table 5), which could either be due to the absence of pressure on the Slovak koruna during this period or due to changes of the central parity at times of pressure. In fact, the later case is more likely as the central parity of the Slovak koruna was revalued twice during its ERM2 membership, and thus relieved pressures from the exchange rate from hitting the strong edge of the band.

The *Slovenian* authorities officially announced a managed floating exchange rate regime for the whole period before ERM2 membership. As there was no explicit change in the exchange rate regime, the specification with breaks would not add any value for this episode. In contrast, we uncover (and model) a policy switch when the Slovenian currency joins the ERM2-system. Officially, this was a change from a managed floating regime towards a

[20] We did this check for all the countries, but only report the results in case of a considerable effect.
[21] For checking the robustness we shortened the sample period. This does not affect the results.

comparatively flexible peg to the euro with very wide bands. Implicitly, however, it was a more pronounced policy shift from a de facto crawling band.[22] As an alternative specification, we turn our attention to the fact that Slovenia's monetary policy, in contrast to the other countries in the sample, officially focused on monetary aggregates. Until 1997 the focus was mainly on base money and M1, but later it switched to M3 (and in 2001 Slovenia even adopted a two pillar strategy). We build in these subperiods with several dummy variables and come to the following conclusion: The inflation coefficient is relatively stable over all periods, the output coefficients become significant but are wrongly signed and the coefficient of the money gap[23] is only significant in the third period. Consequently, we can not retrieve the policy attention for monetary aggregates as it was officially stated.

5. Conclusions

Many central banks in emerging market economies may pay special attention to exchange rate movements, even though they do not officially claim to target the exchange rate. In order to influence exchange rate developments the central bank can basically use two instruments: foreign exchange interventions and interest rate changes. We focus on the later monetary policy instrument by estimating open-economy monetary policy rules, in order to analyse to which extent central banks in Central and Eastern Europe have given the exchange rate a special role in their interest rate decisions.

We estimate monetary policy rules based on a cointegration approach and explicitly take into consideration shifts in exchange rate regimes. The influence of the exchange rate on the interest rate setting behaviour of central banks in CEEC differs strongly between regimes. During periods of more rigid exchange rate arrangements the influence of the exchange rate dominates, i.e. the interest rate policy is mainly influenced by the distance to the intervention margins on which the central bank has to react in order to keep the peg working. During the time periods of more flexible exchange rate arrangements we find a stronger focus on inflation, namely, on the deviation of domestic inflation from the inflation rate set by the Maastricht criterion. This is, in particular, the case for the Czech Republic, Poland and Romania. The inflation coefficient for Slovenia also satisfies the Taylor principle, whereas for Hungary the coefficient is below, but not significantly different from unity.

[22] The band distance variable in this setting only applies for the ERM2-period. Since the exchange rate during did not move close to the margins, the band distance values are negligible and were thus not included in the estimation.
[23] We also included money growth rates as an alternative, but this does not substantially alter the estimation output.

Slovakia remains a special case in the sample. The inflation coefficients do not satisfy the Taylor principle, and it seems that there has been an ongoing focus on exchange rate movements after switching from a fixed exchange rate regime to a managed float. The interest rate setting behaviour indicates an implicit peg, while the two revaluations of the central parity also indicate the challenges to the implicit peg during ERM2-membership.

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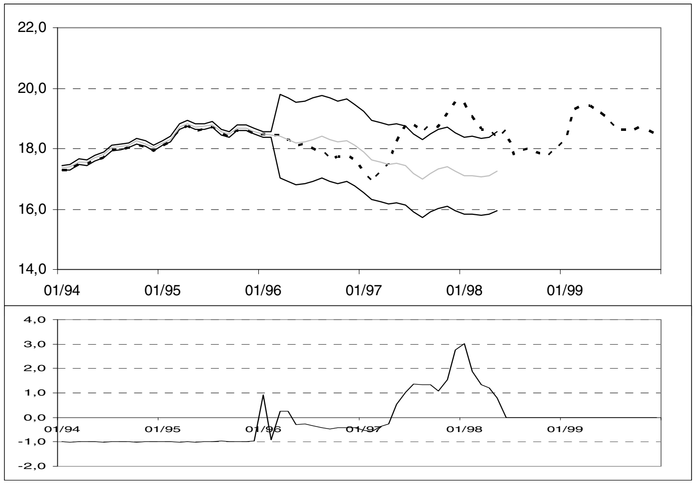
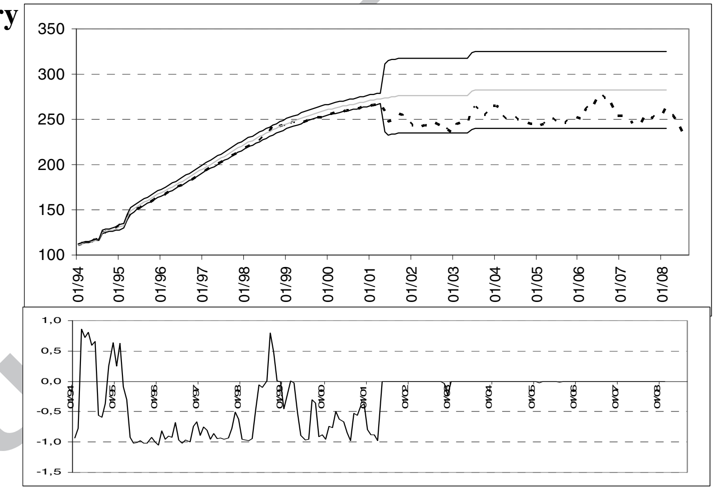
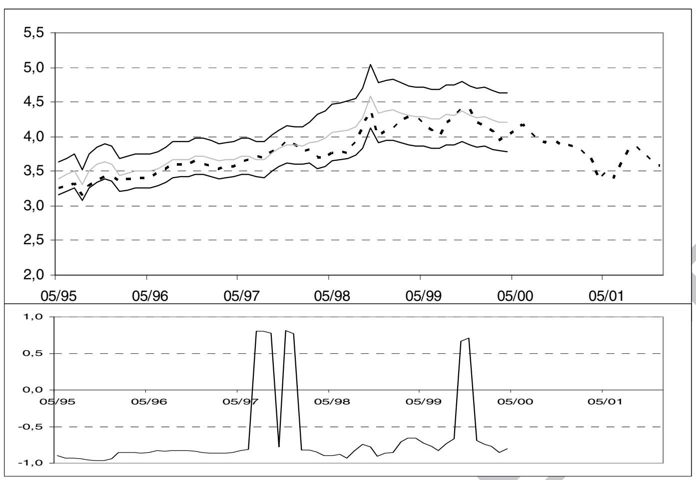
FIGURES 1-4: Derivation of the band distance element from the historical exchange rate peg values. In the upper segment of each graph, the solid black lines represent the strong and weak edge, the gray line denotes the central parity and the market rate is given by the dotted line. In the lower segment, we depict the band distance.



Czech Republic

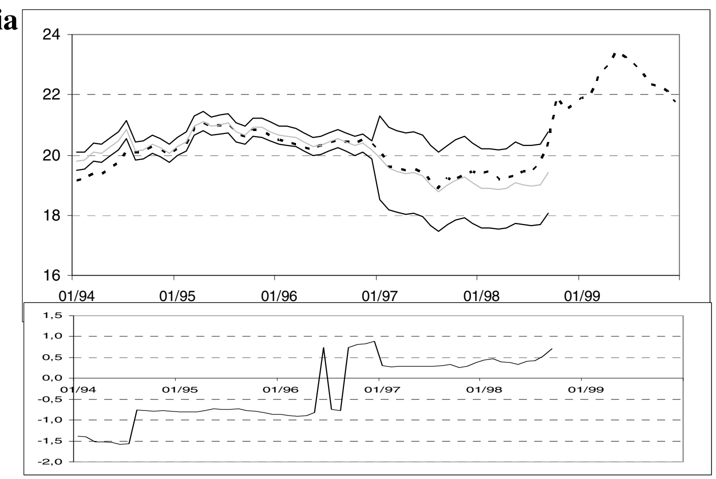
Hungary





Poland

Slovakia



Tables:

TABLE 1: Official Monetary Policy Strategies for Central and Eastern European Countries

Czech Republic		Hungary		Poland	
1994-1997	Exchange rate and monetary targeting (credit volume and M2)	1994-2002	Exchange rate targeting	1994-1998	Exchange rate targeting
1998-2001	Net inflation[1] targeting	2002-	Inflation targeting (CPI annual average)[3]	1998-	Inflation targeting (end of year CPI inflation)
2002-	Headline inflation targeting with linear and declining target band				

Romania		Slovakia		Slovenia	
1994-7/2005	No official commitment to a monetary policy strategy	1994-1998	Exchange rate targeting	1994-1995	Base money targeting
8/2005-2008	Inflation targeting	1998-2008	Informal inflation targeting	1996	Base money and M1-targeting
		11/2005 – 12/2008	ERM-II	1997-2000	M3-targeting[2]
		2009-	Euro system		
				2001-2006	Two-pillar strategy[4]
				06/2004 – 12/2006	ERM-II
				2007-	Euro system

1 Headline inflation minus regulated prices and changes in indirect taxes
2 In Slovenia also including foreign exchange deposits of private households
3 Exchange rate targeting continues in a wide band (±15%)
4 Similar to the strategy of the European Central Bank the Bank of Slovenia bases its monetary policy indicators on two pillars, i.e. indicators of liquidity, and other economic indicators.

TABLE 2: Official Exchange Arrangements for Central and Eastern European Countries

Czech Republic		Hungary		Poland	
01/01/1994-29/02/1996	Basket peg, 65% DEM, 35%USD, Band: ±0.5%	01/01/1994-31/12/1996	Crawling peg[1], 70% Ecu, 30% USD, Band: ±2.25%	01/01/1994-15/05/1995	Crawling peg, 45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF Band: ±1 %
01/03/1996-26/05/1997	Band: ±7.5%	01/01/1997-31/12/1999	70% DEM, 30% USD	16/05/1995-24/02/1998	Band: ±7%
27/05/1997-present	Managed float	01/01/2000-30/04/2001	100% EUR	25/02/1998-31/12/1998	Band: ±10%
		01/05/2001-30/09/2001	Band: ±15%	01/01/1999-11/04/2000	45% USD, 55% EUR
		01/10/2001-25/02/2008	Peg to EUR, Band: ±15%	12/04/2000-present	Free float
		26/02/2008-present	Managed float		
Romania		**Slovak Republic**		**Slovenia**	
since 01/01/1994	Managed float	01/01/1994-31/12/1996	Basket peg, 60% DEM, 40%USD, Band: ±1.5%	01/01/1994-26/06/2004	Managed float
		01/01/1997-30/09/1998	Band: ±7%	27/06/2004-31/12/2006	ERM2
		01/10/1998-24/11/2005	Managed float	since 01/01/2007	Euro Area Member
		25/11/2005-31/12/2008	ERM2		
		since 01/01/2009	Euro Area Member		

Source: IMF, Annual Report of Exchange Rate Arrangements and Restrictions, various issues
[1] Until 16.3.1995, the NBH devalued in discrete steps

TABLE 3: Bounds Testing Approach for Cointegration

Country	Optimal Lag Length	F-Statistic	Lower Bound	Upper Bound
Czech Republic	1	4.522	3.120	4.250
Hungary	5	4.620	3.120	4.250
Poland	1	4.507	3.120	4.250
Romania	6	5.274	3.470	4.570
Slovakia	3	5.189	3.120	4.250
Slovenia	4	4.996	3.470	4.570

TABLE 4: Estimates of the cointegrating vector

		Czech Republic		Hungary		Poland		Romania		Slovakia		Slovenia	
Coefficients		*Time-invariant*	*Structural Break*	*Time-invariant*	*Structural Break*	*Time-invariant*	*Structural Break*	*Time-invariant*	*Structural Break*	*Time-invariant*	*Structural Break*	*Time-invariant*	*Structural Break*
α_π	$\alpha_{1\pi}$	**1.133**	-0.120	**0.878**	**0.868**	**0.685**	**0.555**	**0.324**	0.118	0.239	0.316	**1.306**	**1.453**
		(0.000)	(0.805)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.002)**	(0.157)	(0.125)	(0.527)	**(0.000)**	**(0.000)**
	$\alpha_{2\pi}$	-	**1.021**	-	**0.903**	-	**1.134**	-	**1.120**	-	**0.344**	-	1.050
		-	**(0.000)**	-	**(0.000)**	-	**(0.000)**	-	**(0.000)**	-	**(0.002)**	-	(0.059)
β_Y	β_{1Y}	-0.199	-0.093	-0.121	**-0.194**	0.031	0.058	-0.251	-0.940	0.303	0.118	**-0.526**	**-0.592**
		(0.133)	(0.342)	(0.119)	**(0.007)**	(0.666)	(0.505)	(0.378)	(0.150)	(0.352)	(0.666)	**(0.001)**	**(0.000)**
	β_{2Y}	-	**-0.331**	-	-0.108	-	0.060	-	-0.006	-	-0.160	-	**-0.430**
		-	**(0.018)**	-	(0.170)	-	(0.465)	-	(0.981)	-	(0.478)	-	**(0.008)**
γ_B	γ_B	**1.628**	**2.619**	**1.072**	**1.695**	**1.325**	**1.381**	-	-	**3.636**	**5.908**	-	-
		(0.085)	**(0.007)**	**(0.032)**	**(0.000)**	**(0.004)**	**(0.008)**	-	-	**(0.033)**	**(0.001)**	-	-
δ_S	δ_{1S}	**0.338**	0.285	0.120	0.152	-0.015	-0.015	**-0.506**	0.906	1.002	1.208	0.8324	1.443
		(0.035)	(0.137)	(0.203)	(0.489)	(0.044)	(0.307)	**(0.000)**	(0.554)	(0.207)	(0.163)	(0.403)	(0.109)
	δ_{2S}	-	0.243	-	0.095	-	-0.000	-	-0.380	-	**1.245**	-	-3.462
		-	(0.210)	-	(0.418)	-	(0.999)	-	(0.093)	-	**(0.037)**	-	(0.222)
	ψ_D	-	**-9.741**	-	**-1.811**	-	**-6.091**	-	**-53.466**	-	**-7.002**	-	**3.318**
		-	**(0.017)**	-	**(0.034)**	-	**(0.000)**	-	**(0.000)**	-	**(0.050)**	-	**(0.001)**
R^2_{adj}		0.545	0.653	0.771	0.858	0.613	0.819	0.391	0.531	0.093	0.232	0.576	0.673
DW		1.860	1.759	1.454	1.300	1.313	0.909	1.402	1.245	2.170	1.882	2.234	2.135

"Time-invariant" is the estimate for the benchmark equation (4) $i_t = c + \alpha\pi_t^* + \beta y_t^* + \delta\Delta s_t + \gamma b_t + \sum_{k=-1}^{l}(\alpha_{\pi k}\Delta\pi_{t+k} + \beta_{yk}\Delta y_{t+k} + \delta_{sk}\Delta^2 s_{t+k} + \gamma_{bk}\Delta b_{t+k}) + \eta_t$, "Structural Breaks" for equation (5) with regime-dependent coefficients: $i_t = c + \psi d_t + \alpha_1\pi_{1t}^* + \alpha_2\pi_{2t}^* + \beta_1 y_{1t}^* + \beta_2 y_{2t}^* + \delta_1\Delta s_{1t} + \delta_2\Delta s_{2t} + \gamma b_t + \sum_{k=-1}^{l}(\alpha_{\pi k}\Delta\pi_{t+k} + \beta_{yk}\Delta y_{t+k} + \delta_{sk}\Delta^2 s_{t+k} + \gamma_{bk}\Delta b_{t+k}) + \eta_t$

We employ the following break dates: the Czech Republic (27/05/1997), Hungary (1/05/2001), Poland (25/03/1999), Romania (31/12/1998), Slovakia (1/10/1998) and Slovenia (27/06/2004). All of these represent a move into more "flexible arrangements, except for Slovenia (ERM2). P-values in parenthesis. Estimates of the auxiliary coefficient c not reported.

TABLE 5: Estimates of the cointegrating vector for alternative specifications

	Czech R.	Hungary	Poland	Romania		Slovakia		Slovenia
$\alpha_{1\pi}$	**0.799**	**0.772**	**0.528**	0.100	**$\alpha_{1\pi}$**	0,298	**$\alpha_{1\pi}$**	**1.295**
	(0.005)	**(0.000)**	**(0.000)**	(0.187)		(0,548)		**(0.000)**
$\alpha_{2\pi}$	**1.115**	**0.967**	**1.057**	**0.983**	**$\alpha_{2\pi}$**	**0,350**	**$\alpha_{2\pi}$**	**1.083**
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**		**(0,001)**		**(0.002)**
β_{1Y}	-0.125	-0.053	0.026	-1.030	**β_{1Y}**	0,110	**β_{1Y}**	**-0.628**
	(0.144)	(0.591)	(0.774)	(0.106)		(0,682)		**(0.000)**
β_{2Y}	**-0.166**	-0.123	0.063	0.082	**β_{2Y}**	-0,171	**β_{2Y}**	**-0.412**
	(0.024)	(0.151)	(0.464)	(0.588)		(0,443)		**(0.005)**
γ_B	**1.006**	**1.085**	**1.301**	-	**γ_{1B}**	**5,973**	**δ_{1S}**	1.196
	(0.041)	**(0.014)**	**(0.009)**	-		**(0,000)**		(0.292)
δ_{1S}	0.167	0.168	**-0.103**	**-0.526**	**γ_{2B}**	-0,306	**δ_{2S}**	0.259
	(0.320)	(0.350)	**(0.001)**	**(0.000)**		(0,895)		(0.929)
δ_{2S}	**0.251**	0.137	**-0.107**	0.324	**δ_{1S}**	1,225	**σ_{1M}**	-0.395
	(0.043)	(0.177)	**(0.010)**	(0.352)		(0,158)		(0.432)
ψ_D	**-1.361**	**-3.561**	**-6.683**	**-58.762**	**δ_{2S}**	**1,264**	**σ_{2M}**	0.278
	(0.043)	**(0.003)**	**(0.000)**	**(0.000)**		**(0,037)**		(0.179)
ψ'_D	**9.742**	-	-	-	**ψ_D**	**-7,184**	**σ_{3M}**	**-0.219**
	(0.000)	-	-	-		**(0,040)**		**(0.008)**
R^2_{adj}	0.708	0.849	0.814	0.581	**R^2_{adj}**	0,239	**R^2_{adj}**	0.683
DW	0.899	1.434	0.933	1.396	**DW**	1,860	**DW**	2.052

P-values in parenthesis. Estimates of the auxiliary coefficient c not reported. We add a crisis dummy in the equation for the Czech Republic: $i_t = c + \psi d_t + \psi' d'_t + \alpha_1 \pi^*_{1t} + \alpha_2 \pi^*_{2t} + \beta_1 y^*_{1t} + \beta_2 y^*_{2t} + \gamma b_t + \delta_1 \Delta s_{1t} + \delta_2 \Delta s_{2t} + \sum_{k=-1}^{l} (\alpha_{\pi k} \Delta \pi_{t+k} + \beta_{yk} \Delta y_{t+k} + \delta_{sk} \Delta^2 s_{t+k} + \gamma_{bk} \Delta b_{t+k}) + \eta_t$.

We opt for the classical structure of equation (5) for Hungary, Poland and Romania, but with their country-specific characteristics. Break date adjustments for Hungary (01/06/1999) and Romania (1/12/1998), otherwise this date complies with the information in table 4. In Poland we examine the length of the band distance.

The Slovakian estimation also incorporates bands for ERM2: $i_t = c + \psi d_t + \alpha_1 \pi^*_{1t} + \alpha_2 \pi^*_{2t} + \beta_1 y^*_{1t} + \beta_2 y^*_{2t} + \gamma_1 b_{1t} + \gamma_2 b_{2t} + \delta_1 \Delta s_{1t} + \delta_2 \Delta s_{2t} + \sum_{k=-1}^{l} (\alpha_{\pi k} \Delta \pi_{t+k} + \beta_{yk} \Delta y_{t+k} + \delta_{sk} \Delta^2 s_{t+k} + \gamma_{bk} \Delta b_{t+k}) + \eta_t$.

Finally, for Slovenian we add monetary variables: $i_t = c + \alpha_1 \pi^*_{1t} + \alpha_2 \pi^*_{2t} + \beta_1 y^*_{1t} + \beta_2 y^*_{2t} + \delta_1 \Delta s_{1t} + \delta_2 \Delta s_{2t} + \sigma_{1M} M_{1t} + \sigma_{2M} M_{2t} + \sigma_{3M} M_{3t} + \sum_{k=-1}^{l} \alpha_{\pi k} \Delta \pi_{t+k} + \beta_{yk} \Delta y_{t+k} + \delta_{sk} \Delta^2 s_{t+k} + \sigma_{Mk} \Delta M_{t+k}) + \eta_t$

We estimate monetary policy rules for six central and eastern European countries.
We take changes in the policy settings explicitly into account.
The exchange rate impact is split up into two different components.
In contrast to most empirical work our estimates satisfy the Taylor principle.
The focus in most countries switched from defending the peg to targeting inflation.