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Nominal Anchors in EU Accession Countries – Recent Experiences

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Nominal Anchors in EU Accession Countries – Recent Experiences*

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1. Introduction:

1.1 Objectives and procedure

Which nominal anchor can EU accession countries choose on their way to EMU? In principle several options exist, though inflation targeting seems to be the most popular one at present, e.g. using the exchange rate or a monetary aggregate as an intermediate target, or even using an implicit nominal anchor. Most economists view an implicit nominal anchor as highly discretionary and thereby less credible. Additionally, many EU accession countries regard monetary and exchange rate targeting also as inferior to inflation targeting: They view monetary targeting as unsuitable in an environment of ongoing emergence of financial innovations and gradual opening of capital accounts. However, an explicit exchange rate target may be too vulnerable to speculative attacks especially after their entry into ERM 2.

Nonetheless, why are exchange rate movements important for EU accession countries? Most of them belong to the class of small open economies and thus are highly susceptible to exchange rate movements. Furthermore, some of these countries have tried to strike a delicate balance between lowering inflation and preserving competitiveness. Accordingly, a real appreciation is sometimes less perceived as a fundamental development than as a "bubble", which central banks try to reverse by interest rate changes or by interventions combined with costly sterilization. Moreover, entering the ERM 2 with an "overvalued" exchange rate would challenge a quick entry to EMU, as during the minimum of two years, nominal revaluation but certainly not devaluation may be allowed.

And why will exchange rate movements still be important even if the countries have subsequently chosen other strategies? Even pure inflation targeting usually includes the exchange rate as one of several inflation indicators, though the credibility of the strategy requires that monetary policy should not aim at targeted levels of the exchange rate. The exchange rate objective has to be clearly subordinated to the inflation target. Nevertheless, due to the significant pass-through-effect in small open economies monetary policy may pay special attention to exchange rate movements because the exchange rate has an important impact on inflation. Disruptive exchange rate volatility arising from a thin foreign exchange market or temporary shocks could be further reasons to smooth exchange rate movements, even if countries maintain official floating exchange rate regimes with inflation targeting frameworks (Carare et al., 2002, p. 3-5). However, at times it might be hard to distinguish, whether the inflation target or the exchange rate target is the predominant objective of the

central bank. In other words: countries may officially declare that they pursue a managed floating exchange rate regime with price stability as the ultimate goal, but implicitly, they may also pursue an unannounced exchange rate target for other reasons, e.g. in order to preserve external competitiveness. In this case, the authorities' self description of exchange rate regimes differs from the de facto regimes.[1]

The paper addresses these questions by looking at the recent experience of selected EU accession countries in Central and Eastern Europe. First, we summarize nominal anchors, these countries have *officially* chosen and evaluate the success of their implementation. Then we assess the degree of *implicit* exchange rate targeting by comparing Central and Eastern European countries over time and between each other. We therefore use static and dynamic volatility measures, frequency distributions and regression analysis for sub-periods during which different official regimes prevailed.

The study concentrates on the Czech Republic, Hungary, Poland, Romania, the Slovak Republic and Slovenia, six EU accession countries in Central and Eastern Europe and on the time period since 1994. Whereas the Czech Republic, Hungary, Poland and the Slovak Republic have shifted from more fixed to more flexible exchange rate regimes, Slovenia and Romania have announced managed floating exchange rate regimes during the entire sample period. Accordingly, the study excludes EU accession countries which have opted for very hard pegs as the currency board regimes in Bulgaria, Estonia and Lithuania, and the pegged regime in Latvia.

1.2 Current state of the art in the research field

If we assume that countries have continued to pursue exchange rate targets even though they officially claim to target other nominal anchors, the most relevant literature to this topic is the literature on de facto exchange rate regimes. Generally, two approaches may be taken to disentangle de facto exchange rate regimes from the officially announced arrangements. The first one looks at the instruments, with which the central bank tries to manage exchange rate movements, i.e. official reserves and interest rates. Popper and Lowell (1994) use this approach and study changes in foreign reserve holdings and the behavior of prices in response to exchange rate changes for four Pacific Basin countries. The second

[1] This well known feature has also been acknowledged by the IMF, see Fischer (2001). For a discussion on exchange rate arrangements, chosen in transition countries, see Mussa et al. (2000).

approach looks at the results of the exchange rate policies, i.e. at the variations of exchange rates. Studies, which follow this approach, are Haldane and Hall (1991), who analyze the Sterling's transition from a dollar peg to a DM peg. Frankel and Wei (1992, 1993) evidence an increasing influence of the yen in the nominal exchange rate policies of some Asian countries since the early 1980s. Furthermore, Bénassy-Quéré (1996) concludes that Western Europe constituted a strong monetary bloc pegging to the DM during 1989-1995 that was not pulled down by the ERM crises. She also concludes, that Eastern European countries did not adopt a DM nominal peg during this early period, although included the DM in their de facto basket peg. In contrast, Asian countries rarely weighed the yen in their implicit basket pegs and their peg to the US Dollar was loser than for European currencies vis-à-vis the DM.

More recent studies use both approaches in order to study de facto exchange rate regimes. Calvo and Reinhart (2000) compare volatilities of the exchange rate, interest rate and international reserves across 154 exchange rate arrangements and use a vector autoregression analysis to study these variables. Levy-Yeyati and Sturzenegger (2000) construct a de facto classification of exchange rate regimes, using cluster analysis techniques for data from all IMF-reporting countries over the period 1974-99. In this approach different regimes are grouped according to the behavior of the exchange rates and international reserves. Neither study supports the hypothesis that intermediate regimes have been de facto disappearing in recent years, but indicates that countries that claim to pursue a floating exchange rate regime mostly do not.

Frankel et al. (2001) test the verifiability of official exchange rate regimes, a related topic. They use regression analysis to investigate whether and how the exchange rate is given by a weighted combination of foreign currencies taking into account possible rates of crawl. Their findings support that more complicated regimes with basket pegs, wider or frequently changing bands are harder to verify and that this may be a reason for the popularity of corner solutions. For a small sample of countries with officially declared floating exchange rate regimes (Brazil, Mexico, Peru, South Korea and Thailand) their tests do not yield any evidence against the hypothesis that the exchange rates of these countries are indeed floating, with the exception of Peru and part of the post-Tequila period in Mexico.

A paper explicitly dealing with de facto and official exchange rate regimes in *transition* countries is that by von Hagen and Zhou (2002). In a sample of 25 transition countries they use probit models to describe the joint determination of the two regime choices and the determination of regime discrepancies. They find that official regimes are more

persistent and change in less frequent but larger steps than de facto regimes do. Also apart from other factors they find that countries with more developed monetary systems are more likely to adopt an official floating-rate regime, thus supporting the fact that some Central and Eastern countries moved to more flexible arrangements on their way to EU accession.

2. Official Nominal Anchors – a Look at Recent Experiences

Usually emerging markets use some form of fixed exchange rates in the early stages of disinflation until they progress to other strategies. This can be witnessed in four out of the six countries which we investigate in our sample. The Czech and the Slovak Republic, Hungary and Poland have moved from rather fixed to more flexible exchange rate arrangements. Hungary and Poland have chosen crawling peg or band regimes in the early stage and the Czech and the Slovak Republic exchange rate regimes with horizontal pegs, whereas Slovenia and Romania has had managed floating regimes over the entire sample period.[2] In table A1 in the appendix the official exchange rate regimes of the six countries since 1994 are summarized in more detail. Each country can be separated in different regimes depending not only on the choice between fixed or flexible exchange rates but also on the width of the band. This section gives a short overview about the strategies, which have been chosen by these countries while officially moving away from exchange rate targeting and how successful they have been.

Czech Republic

After the Czech Republic moved to a managed floating exchange rate regime in 1997, it introduced inflation targeting in 1998. The Czech National Bank (CNB) officially explained this step by the exchange rate crisis in spring 1997, during which the nominal anchor provided by exchange rate targeting had to be abandoned. Additionally the CNB viewed the demand for money as too unstable in an environment of major financial innovations and a liberalized capital account for introducing a monetary aggregate as an intermediary target (Annual report of the CNB 1998, p. 48). So far there have been two sub-periods of inflation targeting: During 1998-2001 the CNB pursued net inflation[3] targeting with an end-year target range. By using a core CPI the central bank excludes components that are beyond its control, though this

[2] The IMF defines a managed float as a flexible exchange rate regime "with no predetermined path for the exchange rate" (Ishii and Habermeier 2002, p. 344).
[3] Headline inflation minus regulated prices and changes in indirect taxes

measure of inflation is less familiar to the public and therefore may be less credible. Since 2002[4] the CNB has shifted to headline inflation targeting with a continuous linear and declining target band. Escape clauses are incorporated into the new strategy and allow a deviation from the announced target. Among the possible influences are also deviations of the koruna's exchange rate that are not connected with domestic economic fundamentals and domestic monetary policy. So in principle, this shelters the CNB from having an implicit exchange rate target while officially pursuing inflation targeting: it is not forced to engage in exchange rate smoothing should exchange rate shocks jeopardize meeting the announced target.

TABLE 1. Inflation targeting in the Czech Republic

Net inflation targeting			
Target date	**set in**	**Target level***	**Actual inflation**
Dec. 1998	Dec. 1997	5.5-6.5%	below (3.8%)
Dec. 1999	Nov. 1998	4-5%	below (1.5%)
Dec. 2000	Dec. 1997	3.5-5.5%	below (3.0%)
Dec. 2001	April 2000	2-4%	within (2.4%)
Dec. 2005	April 1999	1-3%	
Headline inflation targeting			
Target period	**set in**	**Target level***	**Actual inflation**
Jan. 2002 - Dec. 2005	April 2001	3-5% to 2-4%	

* end-year target range ** linear declining band

Source: Annual Report of the CNB

As shown in Table 1 the success of inflation targeting was rather mixed. Since the introduction of inflation targeting in 1998 the CNB undershot the target three out of four times. The official explanations were focused on exceptional developments, which were beyond the reach of the central bank's monetary policy. Undershooting the target is not

[4] announced in April 2001

unusual to countries that are disinflating. They rather accept below-target inflation outcomes and take advantage of unexpected disinflationary outcomes to announce lower targets (Carare et al., 2002, 13-14). Nevertheless, it may have a negative impact on credibility as the impression can arise that there are too many factors beyond the control of the central bank even though it already uses a core CPI.

Hungary

Until recently Hungary managed the nominal exchange rate in a fairly narrow crawling band. In 2001 the National Bank of Hungary (NBH) widened the band substantially, then introduced a horizontal band and adopted inflation targeting. The inflation target is surrounded by a +/-1 percent tolerance band and was achieved in 2001. The medium term strategy is to prevent inflation exceeding 3.5 percent by December 2003.[5]

Poland

Until 1998, the National Bank of Poland (NBP) attempted to conduct a monetary policy by combining the elements of monetary and exchange rate targeting: The intermediate target was to increase the money supply under conditions of crawling devaluation of the Zloty vis-à-vis the basket of currencies. This strategy did not allow meeting the two intermediate targets in full, although initially, it allowed for reducing inflation.[6] The NBP widened the band substantially and introduced direct inflation targeting in 1998 by arguing with the advancing integration of the Polish financial markets with the global markets. The inflation target is defined with regard to the consumer price inflation at the end of the year. The medium term strategy aims at reducing inflation below 4% by the end of 2003. However, each year short term inflation targets are announced.

The NBP so far has never hit its short term target as is shown in Table 2: it equally undershot and overshot its target during the last four years. As in case of other inflation targeters, the NBP has usually explained the failure to achieve the target by citing external factors, which it has been unable to influence.

[5] Web page of the NBH, Annual Report 2001
[6] NBP, Medium-Term Monetary Policy Strategy, 1999-2003

TABLE 2. Inflation targeting of the NBP

Year	Inflation target	Actual inflation
1998	< 9.5%	Below (8.6%)
1999	6.6-7.8%	Above (9.8%)
2000	5.4-6.8%	Above (8.5%)
2001	6-8%	Below (3.6)

Source: Annual Report of the NBP

Romania

Romania has had a managed floating exchange rate regime during the entire sample period. However, the exchange market has only been liberalized since 1997. The National Bank of Romania (NBR) has no explicit commitment to a specific exchange rate or inflation path. It perceives base money management as the most viable method to contain inflation,[7] though this target has often been overruled by quasi-fiscal objectives. Although in 1997, directed credit by the central bank were terminated, quasi-fiscal interests have still jeopardized price stability, e.g. liquidity injections have at times supported ailing state banks.[8]

Slovakia

After the Slovak Republic moved to a managed floating exchange rate regime in October 1998, it has used inflation bands as an informal guide for monetary policy since 1999. However, it does not call its strategy a formal inflation targeting.[9] In the Revised Monetary Program of the National Bank of Slovakia (NBS) the inflation band is defined as year-end consumer price inflation. If the inflation rate approaches the limits of the band, the NBS will take action to reassess its policies. As shown in Table 3 the NBS undershot two out of three times its informal inflation target.

[7] NBR, various annual reports
[8] IMF, Selected Issues and Statistical Appendix, 6.11.02, http//www.imf.org
[9] The NBS does not make an inflation forecast, nor does it issue inflation reports, but it does explain deviation from the target band in its annual report.

TABLE 3. Informal Inflation targeting of the NBS

Year	Inflation band	Actual inflation
1999	13.5-15.5%	within (14.2%)
2000	8.8-9.9%	below (8.5%)
2001	6.7-8.2%	below (6.5%)

Source: Annual reports of the NBS

Slovenia

Slovenia has had a managed floating exchange rate regime over the entire sample period. Until 2000 it used a monetary aggregate as a nominal anchor, which the authorities have officially explained by greater discipline, transparency, and credibility than an inflation targeting framework. This benefit would offset the concerns about the stability of money demand in a changing financial environment. Several sub-periods of monetary targeting can be distinguished: During 1994-95 the Bank of Slovenia (BoS) targeted base money, in 1996 also M1 and since 1997 it explicitly declared M3 as its intermediate target and announced a target band. Slovenian M3 includes foreign exchange deposits of private households, which comprise about 30% of M3.[10] Thus, exchange rate movements also influence M3 growth (e.g. a depreciation of the tolar raises the value of foreign exchange deposits and vice versa).

TABLE 4: M3 growth-targeting of the BoS

Target date	set in	Target level*	Actual M3 growth
1997	May 1997	14-22%	within (20.9%)
1998	March 1998	18-26%	within (20.1%)
1999	Jan 1999	16-24%	within (16.0%)
2000	Jan 2000	12-18%	within (16.3%)
2001	Jan 2001	11-17%	above (23.9%)

* defined as the fourth quarter average over the corresponding period of the previous year

Source: Annual Report of the BoS

[10] Average of end year data for 1999-2001

In Table 4 the actual and targeted M3 growth is shown since 1997. The BoS mostly hit its intermediate target, though the formulation of quite wide target ranges (6 to 8%-points) facilitated this outcome, but also made the strategy less credible.

In 2001 the BoS switched to a new monetary policy framework, which is more similar to inflation targeting, as it bears some of its hallmarks, e.g. the announcement of a medium-term inflation objective (4% by the end of 2003) or the publication of updated inflation forecasts. Similar to the strategy of the ECB the BoS bases its monetary policy indicators on two pillars: indicators of liquidity, and other economic indicators, as for example the exchange rate, foreign interest rates, wages and growth in administered prices.[11]

Summing up so far, there has been a general shift to more flexible exchange rates and the more advanced EU accession countries have subsequently looked for other nominal anchors than the exchange rate. However, there is no clear evidence how determined or how capable they were in achieving other nominal anchors: Some of them have often missed to hit their official targets, others have chosen quite wide bands. So, even if these countries have officially moved to more flexible arrangements, they may have still paid attention to exchange rate movements. To which extent they may have done so is the objective of the following section.

3. Implicit Exchange Rate Targeting – Some Evidence

3.1 Volatility and Frequency Distribution

We first investigate the volatility of exchange rates, foreign exchange reserves and interest rates in order to find some evidence for implicit exchange rate targeting. The underlying idea is that even in countries which announce to have floating exchange rates shocks to the exchange rate are accommodated through purchases and sales of foreign exchange reserves or through interest rate movements. Accordingly, the volatility of foreign exchange rates is fairly low, whereas the volatility of foreign exchange reserves and interest rates is relatively high.[12]

[11] BoS Annual Report, p. 23

[12] However, this approach is not suitable for detecting very credible fixed exchange rate regimes, as in this case, a low volatility of the exchange rate would be coupled with a low volatility of reserves and interest rates.

We compare two sets of observations during the time period January 1994 to April 2002 in Table 5a and 5b. The first set, called FIX, includes the countries, which have officially announced to have had fairly fixed exchange rate regimes during the country specific time period.[13] The second set, called FLOAT, shows the volatility of exchange rates, reserves and interest rates for the specific time periods, in which countries have officially declared to have floating exchange rate regimes.[14]

TABLE 5a. Volatility of exchange rates, reserves and interest rates, FIX

	Czech Rep.	Poland	Hungary	Slovak Rep.
Exchange rate[1]	1.0	2.1	0.7	0.6
Reserves (normalized)[2]	5.0	5.7	10.2	10.4
Interest rate[3]	1.4	2.3	0.9	1.7

TABLE 5b. Volatility of exchange rates, reserves and interest rates, FLOAT

	Czech Rep.	Poland	Hungary	Slovak Rep.	Slovenia	Romania
Exchange rate[1]	1.6	2.7	1.8	1.8	0.6	5.9
Reserves (normalized)[2]	3.4	6.1	7.9	9.3	18.8	8.9
Interest rate[3]	1.5	1.3	0.3	1.1	3.2	11.7

Source: monthly data, IFS (see Appendix for details)
Exchange rate volatility measured to basket or DEM (EUR) adjusted for announced devaluation in case of crawling peg regimes
* Countries with official managed or free floating exchange rate regimes
[1] Standard deviation of monthly percentage changes of nominal exchange rates
[2] Standard deviation of monthly changes of foreign exchange reserves deflated by the monetary base
[3] Standard deviation of monthly changes in interest rates (percentage points)

Exchange rates are measured against their respective anchor. In case of floating exchange rate regimes, the D-Mark or Euro is chosen as the implicit anchor and in case of crawling peg regimes the changes have been adjusted for the pre-announced depreciation rate in order to avoid announced shifts in the crawling pegs to be calculated as volatility.[15] Changes of foreign exchange reserves are normalized, i.e. they are deflated by base money.

[13] Czech Republic: Jan. 1994 – May 1997, Hungary: Jan. 1994 – Apr. 2001, Poland: Jan. 1994 – Mar. 2000, Slovak Republic: Jan. 1994 – Sep. 1998
[14] Czech Republic: June 1997 – Apr. 2002, Hungary: May 2001 – Apr. 2002, Poland: Apr. 2000 – Apr. 2002, Slovak Republic: Oct. 1998 – Apr. 2002, Slovenia: Jan. 1994 – Apr. 2002, Romania: Jan. 1994 – Apr. 2002
[15] For a similar analysis for exchange rate volatility including some Ex-Yugoslav countries see Schobert (2001)

We use this ratio to approximate the monetary impact of the change in reserves.[16] Some care must be taken when using changes in reserves as an indicator for intervention. Reserves may change owing to fluctuations in valuation and the accrual of interest earnings, or some growth may simply be desired to keep pace with the size of the market. Interest rate changes are another instrument to smooth exchange rate fluctuations and it assumes that especially in emerging market countries they may not predominantly be set with domestic, but with external policy objectives in mind.

Comparing the observations Slovenia is a case apart as it exhibits the highest volatility of reserves and a fairly high volatility of interest rates, but the lowest exchange rate volatility. This occurred despite the fact that it declared that it has had a managed floating exchange rate during the entire sample period. Accordingly, the indicators point at Slovenia as a likely candidate for implicit exchange rate targeting. The observations for Poland do not differ much between the two regimes probably due to the fact, that the exchange rate bands have been widened substantially before Poland officially declared a floating exchange rate regime. The most volatile exchange rate is observed for Romania though coupled with fairly volatile reserves and interest rates.

We now investigate frequency distributions of key indicators for exchange rate regimes. Looking at Tables 6a and 6b the probability of staying within a predetermined band is given for the exchange rate, for reserves, for base money and for the interest rates. The method (including the choice of the band width) is based on Calvo and Reinhart (2000). Their results for different official regimes are shown for comparison in Table 6a. The underlying idea is, that in (implicit or explicit) fixed exchange rate regimes the probability for the exchange rate staying within a predetermined band should be high, whereas the probability for reserves, base money and interest rates should be low.

The probabilities for exchange rates, reserves and base money in officially fixed exchange rate regimes (Table 6a) match this idea, however, the probability for interest rates are inconclusive.[17] The results for officially floating exchange rate regimes (Table 6b) again indicate implicit exchange rate targeting for Slovenia. The probability of the exchange rate staying within a predetermined band has been highest, whereas the respective probabilities for

[16] This normalization is quite common in the literature, e.g. in Popper and Lowell (1994) or in Sturzenegger and Yeyati (2000), though some studies use other denominator, e.g. M3 in von Hagen and Zhou (2002).
[17] A low probability of the interest rate staying within a narrow band might be due to a combination of trying to stabilize the exchange rate through open market operations *and* lack of credibility, see also Calvo and Reinhart (2000)

reserves, base money and interest rates have been fairly low. For the other countries the evidence of implicit exchange rate targeting is less clear-cut. Poland actually seems to be closest to a "true float" with regards to the indicators for the exchange rate and for reserves taking the Calvo/ Reinhart results for the USA as the reference.

TABLE 6a. Probability that x lies within the band in fixed exchange rate regimes

	FIX				Calvo/ Reinhart**			
X*	**Czech Rep.**	**Poland**	**Hungary**	**Slovak Rep.**	**fix**	**lim. flex**	**man. float**	**USA[1]**
Exchange Rate [2]								
1% band	80.5	64.0	84.1	86.0	83.1	64.6	60.1	26.8
2.5% band	97.6	82.7	100.0	100.0	95.9	92.0	87.5	58.7
For. Ex. Reserves								
1% band	19.5	29.3	14.8	17.5	15.4	20.8	17.8	28.6
2.5% band	36.6	52.0	33.0	38.6	36.5	45.9	39.2	62.2
Base Money								
1% band	17.1	14.7	28.4	14.0	17.6	17.9	19.9	42.1
2% band	36.6	20.0	59.1	29.8	34.2	32.2	36.5	67.2
Interest Rate								
25 bps	41.5	16.0	46.6	31.6	52.3	47.5	36.3	59.7
50 bps	65.9	33.3	68.2	50.9	69.3	68.7	49.4	80.7

TABLE 6b. Probability that x lies within the band in floating exchange rate regimes

	FLOAT					
X*	**Czech Rep.**	**Poland**	**Hungary**	**Slovak Rep.**	**Slovenia**	**Romania**
Exchange Rate[2]						
1% band	72.9	20.0	41.7	55.8	85.0	26.0
2.5% band	98.3	64.0	83.3	90.7	100.0	55.0
For. Ex. Reserves						
1% band	69.5	32.0	16.7	18.6	19.0	12.0
2.5% band	86.4	68.0	33.3	46.5	38.0	30.0
Base Money						
1% band	79.7	12.0	16.7	20.9	10.0	12.0
2% band	89.8	20.0	16.7	25.6	21.0	21.0
Interest Rate						
25 bps	96.6	24.0	58.3	34.9	23.0	6.0
50 bps	100.0	48.0	83.3	51.2	41.0	14.0

Source: monthly data, IFS (see Appendix for details)
* x is defined as % changes (in case of interest rates: changes expressed in basis points, bps)
** Calvo/ Reinhart follow the IMF classification: peg, limited flexibility, managed floating and freely-floating
Their sample uses monthly data for 39 countries during Jan 1970 to April 1999
[1] Exchange rate changes are measured against the D-Mark (Euro)

[2] Exchange rate to the respective basket or to the Euro (DEM) in case of floating regimes, adjusted for pre-announced devaluation in case of crawling peg regimes

In Figure 1 changes in normalized foreign exchange reserve holdings are shown as quarterly data during the sample period. In line with the argument that central banks have substantially reduced the use of official interventions over time, changes in normalized foreign exchange reserves have decreased in most countries, though this is less pronounced in Slovenia.

The combination of changes in normalized foreign exchange reserve holdings plus exchange rate movements provides a measure of the exchange market pressure facing a particular currency.[18] This indicator is shown in figure 2.

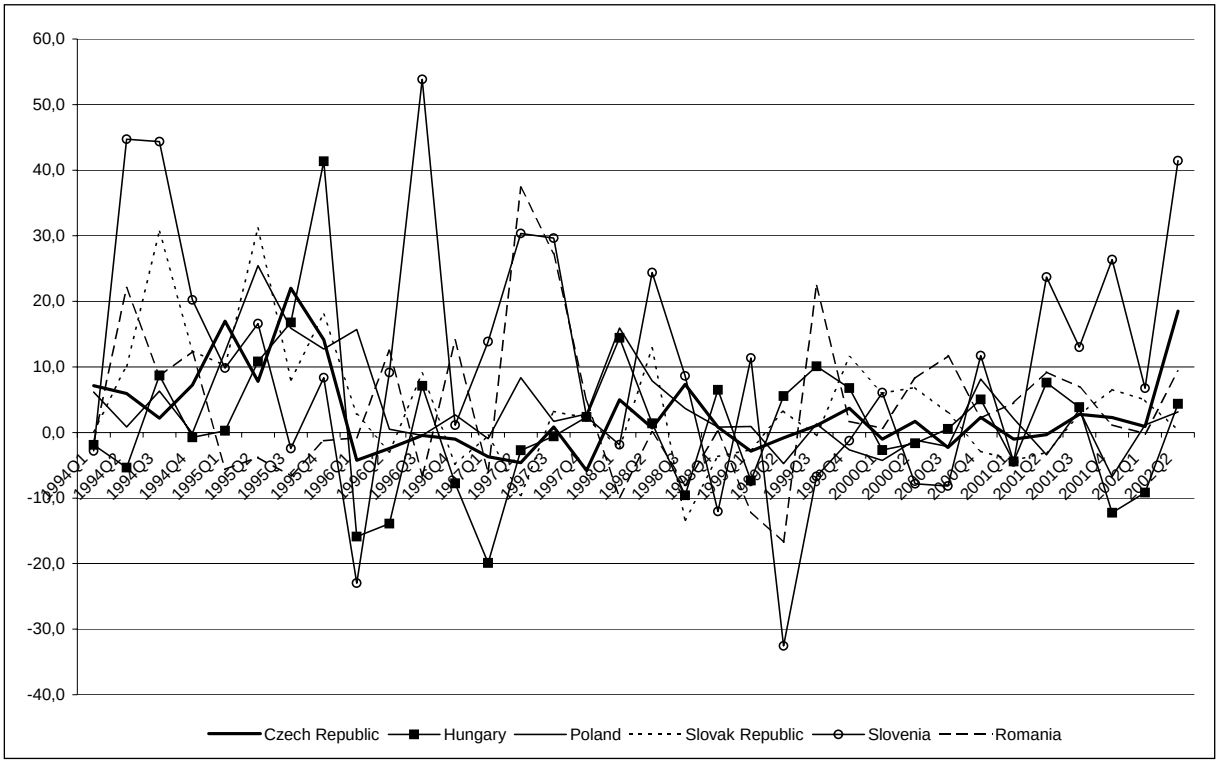
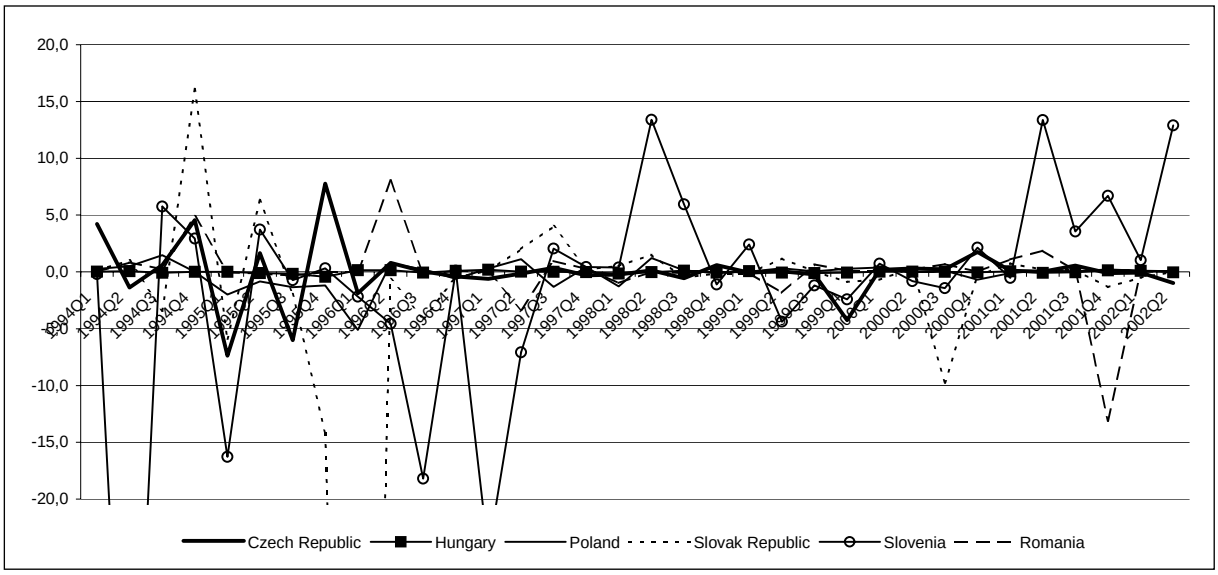


FIGURE 1. Changes in normalized foreign exchange holdings, 1.Q.1994 – 2.Q.2002

[18] See Popper and Lowell (1994), a depreciation or appreciation is measured as the annualized rate of change in the exchange rate over its level at the end of the preceding quarter.

FIGURE 2. Changes in normalized foreign exchange holdings as a ratio to exchange rate movements, 1.Q.1994 – 2.Q.2002



It is an indicator of the degree to which the authorities have succeeded in exchange rate-targeting by interventions in the foreign exchange market.[19] Spikes indicate that large interventions were not accompanied by comparable changes in the exchange rate, while values close to zero indicate minimal foreign reserve movements and /or large exchange rate changes. So keeping in mind that central banks attempted to smooth exchange rate movements, i.e. reacted to exchange rate shocks by using interventions, spikes indicate periods of successful intervention. The visual inspection allows the following interpretation: Whereas in countries like the Czech Republic, interventions have not only decreased, as evidenced in FIGURE 1, but probably have also become less effective, as evidenced in FIGURE 2. This development cannot be observed in Slovenia, which seems to have continued successful interventions.

Summing up so far, we have found some evidence of fear of floating or implicit exchange rate targeting. Combining these findings with a look at figure A1 – A6 in the appendix allows some further thought experiments. Slovenia seems to have pursued an implicit crawling peg regime as its exchange rate followed a smoother upward path than the exchange rates of Poland and Hungary, countries, which officially had crawling peg/ band regimes. Thus, Slovenia again is the most likely candidate to have pursued implicit exchange rate targeting. And as a second finding, central banks occasionally have had difficulties in

[19] Assuming again, that changes in foreign exchange holdings reflect these interventions.

keeping the exchange rate from appreciating. During their fixed exchange rate regimes, exchange rates quite often remained in the lower part of the band. This is most pronounced in Hungary, where the exchange rate at times moved along the lower boundary of the band. However, it can also be observed during several periods in Poland (though it is less striking maybe due to wider bands) and in the mid-nineties in the Czech Republic.[20]

In order to analyze these first findings in more detail we proceed with GARCH-volatility estimations and a regression analysis.

3.2 Evidence from GARCH Volatility Estimations

As the volatility of exchange rates may give some deeper insights in the exchange rate regime followed, we carefully work out this topic. We rely on the well known class of GARCH models (Bollerslev 1986, for a survey see Bollerslev et al. 1992). According to the GARCH model of order one, which is often used to describe the dynamics of exchange rate volatility, the exchange rate return r_t fluctuates around a mean μ with time-varying variance:

$$r_t = \mu + \varepsilon_t \,,\ \varepsilon_t \sim N(0, \sigma_t^2) \tag{1}$$

where the conditional variance is determined by the following equation:

$$\sigma_t^2 = \omega + \alpha \cdot \varepsilon_{t-1}^2 + \beta \cdot \sigma_{t-1}^2 + \sum_{i=1}^{N} d_i \tag{2}$$

where ω, α, β are real numbers and the d_i are a set of dummy variables representing subsequent regimes of exchange rate policies, which may lead to a shift in exchange rate volatility.

We now estimate eq. (1) for the whole period from January 1994 through October 2002. The returns r_t are formed as the difference of logs of the exchange rate. For the rates officially following a crawling peg or crawling basket (the Hungarian forint and the Polish zloty) the returns are corrected for the announced rate of crawl. Therefore we split up the return into the announced and known rate of crawl and the unknown deviation from the central parity, which is the unknown movement within the band. The dummies correspond with the changing exchange rate regimes as given in table A.1, where the current regime in

[20] If these countries were faced with trend real appreciations, as for example mentioned in Masson (1999), they may have partly intervened to limit these trends.

October 2002 is not represented by a dummy. However, the Slovenian tolar and the Romanian leu have been officially announced as managed floating during the entire period. Nevertheless, the plot of the SIT/DEM rate reveals a structural break at the beginning of 1998. The movements of the exchange rate are extremely smooth until 1998 and then become much more volatile. So we include an additional dummy variable for the SIT/DEM rate before 1998. The situation is similar for Romanian leu: our results in section 3.3 indicate a structural change in the exchange rate development in April 1997, probably due to the extensive liberalization of the foreign exchange market. We therefore include an additional dummy variable for this exchange rate, as well.

The estimation results are given in Table 7a and Table 7b for the exchange rates against the Deutsche Mark and the US Dollar. For most exchange rates the sum of α and β is close to one, which means that volatility shocks are highly persistent, but not permanent. The SIT/DEM rate, however, exhibits a different volatility pattern: the sum of α and β exceeds one, that is volatility shocks are not only highly persistent but permanent. This difference to the other rates may be due to the stepwise liberalization of financial markets leading to a continuous increase in exchange rate volatility.

The result, that including most of the dummies significantly improves the fit of the model, matchs the history of the exchange rate regimes. There are only few exceptions: The coefficients d_1 and d_3 for the PLZ/DEM do not significantly contribute to the model, which means that the exchange rate arrangements from 1/1994 through 5/1995 and from 2/1998 through 12/1998 exhibit volatility patterns which are quite similar to the period of the free floating PLZ. The influence of the exchange rate regime on the exchange rate volatility is considered in more detail below.

TABLE 7a. Coefficient for GARCH models against Deutsche Mark respective Euro

	CZK/DEM	HUF/DEM	PLZ/DEM		ROL/DEM	SIT/DEM	SKK/DEM
μ	-0.0056	0.0168****	0.0021	0.0021	0.1072***	0.0039***	-0.0072
ω	0.0039***	0.0102***	0.0024***	0.0021***	0.0271***	0.0009***	0.0025***
α	0.1142***	0.1255***	0.0380***	0.0378***	0.0807***	0.2824***	0.0938***
β	0.8807***	0.8068***	0.9498***	0.9509***	0.8773***	0.7618***	0.8896***
d_1	-0.0024***	0.0024***	0.0001	--	0.0075***	-0.0009***	-0.0005**
d_2	0.0001[3]	-0.0055***	-0.0011**	-0.0009***	--	--	0.0054***
d_3	--	-0.0099***	-0.0007	--	--	--	--
d_4	--	0.0683***	0.0015**	0.0015**	--	--	--
LogL[1]	-879.14	-418,76	-1063.98	-1064.68	-2607.58	3556.68	-472.86
DW[2]	2.0863	2.0093	2.1226	2.1227	1.7654	2.7000[4]	1.8767[4]

[1] Value of the log likelihood function
[2] Durbin Watson test statistic
3 A Wald test indicates that the dummy d_2 does not significantly contribute to the fit, whereas a Likelihood ratio test indicates that it does. We therefore do not remove it from the equation.
[4] After introduction of an additional AR(1) term, which eliminates all autocorrelation in the residuals for the SKK, there still remains some autocorrelation for the SIT.

TABLE 7b. Coefficient for GARCH models against US Dollar

	CZK/USD	HUF/USD		PLZ/USD		ROL/USD	SIT/USD	SKK/USD
μ	-0.0013	0.0477***	0.0482***	0.0098***	0.0010***	0.0952***	0.0253*	0.0087
ω	0.0118***	0.0133***	0.0104***	0.0173***	0.0170***	0.0147***	0.0125***	0.0216****
α	0.0388***	0.1297***	0.1306***	0.0357***	0.0358***	0.5412***	0.0457***	0.0807***
β	0.9418***	0.8557***	0.8570***	0.9506***	0.9516***	0.4899***	0.9321***	0.8846***
d_1	--	-0.0021	--	0.0043	--	0.0962***	-0.0041	-0.0052**
d_2	--	-0.0034	--	-0.0075*	-0.0079***	--	--	-0.0030
d_3	--	0.0235***	0.0248***	-0.0065	--	--	--	--
d_4	--	0.0234**	0.0250**	0.0050	--	--	--	--
						--		
LogL[1]	-2490.87	-1918.60	-1919.01	-3180.67	-3183.30	-1446.70	-2177.80	-2332.89
DW[2]	2.2110	2.0389	2.0389	2.0845	2.0845	1.8435	2.0988	2.3009

[1] Value of the log likelihood function
[2] Durbin Watson test statistic

The results are quite similar for the volatility against the USD with the exception that less dummy coefficients are statistically significant. This may be a first hint that the de facto exchange rate regimes are determined to the Deutsche Mark rather than to the US Dollar, with exception of the Romanian leu.

TABLE 8. Average Conditional Volatility against DEM and USD within subperiods

CZK		HUF		PLZ		ROL		SIT		SKK	
DEM	**USD**	**DEM**	**USD**	**DEM**	**USD**	**DEM**	**USD**	**DEM**	**USD**	**DEM**	**USD**
1/94-2/96		1/94-12/96		1/94-5/95		1/94-3/97		1/94-12/98		1/94-12/96	
0.063	0.548	0.395	0.419	0.142	1.124	0.816	1.185	0.002	0.383	0.073	0.476
3/96-5/97		1/97-12/99		5/95-2/98		4/97-10/02		1/99-10/02		1/97-12/96	
0.178	0.428	0.105	0.266	0.116	0.858	0.708	0.413	0.049	0.531	0.161	0.463
5/97-10/02		1/00-5/01		2/98-12/98						10/98-10/02	
0.272	0.633	0.009	0.886	0.111	0.759					0.156	0.600
		5/01-9/01		1/99-4/00							
		0.813	0.964	0.228	1.219						
		10/01-10/02		4/00-10/02							
		0.165	0.442	0.254	1.487						

By using the volatility estimations from Tables 7a and 7b we compute the average conditional variance for each regime. The results are shown in Table 8. There are two major findings in the results: First, the volatility against the USD is for most currencies much higher than against the DEM. This supports the view that most currencies have been more stable vis-à-vis the Deutsche Mark than vis-à-vis the US dollar. This may not necessarily be due to exchange rate policy, but also hints at a higher integration to the European economy than to the US. The only exception is the Romanian leu between 4/1997 and 10/2002. Whereas the leu was more volatile against the US dollar during the first period, the picture was different for the second one: the high volatility against the Deutsche mark in comparison with the volatility against the US dollar gives a first hint at some kind of pegging to the US dollar for the case of Romania.

Second, the managed floating regimes (this does not apply to the free floating regime in Poland) are not necessarily the most volatile ones for the respective exchange rate. For the Czech koruna and the Slovak koruna, for instance, the volatility does not increase after switching to a managed float, for the latter it rather declines. This fits well to the next section's result that both

countries were not able to achieve their goals during their last period of official pegging and were rather driven by market forces to switch to floating exchange rates.

3.3 Are Announced Exchange Rate Regimes Verifiable?

After the analysis of volatility has given some first insights to the de facto exchange rate regimes, we will now try to assess whether the official pegs and baskets have been credible and verifiable.

In a first step we consider the deviation from the announced central parity. It emerges from the following equation:

$$s_t = \text{const.} + CP_t + \varepsilon_t \qquad (3)$$

where s_t is the exchange rate of the currency under observation against a numeraire and CP_t is the central parity of the exchange rate band. If the authority is successful in pegging the exchange rate, the error term ε_t must be stationary. Testing the error term ε_t for a unit root then turns out to be a test whether the announced fixed exchange rate regime is working or not. This approach can, of course, not be applied to currencies or periods for which no central parity was announced, these are the managed floats of the Czech koruna (since 5/1997) and the Slovak koruna (since 10/1998), the free float of the Polish zloty (since 4/2000), the Slovenian tolar and the Romanian leu. The results for the remaining periods are given in Table 9. Note that we do not need to use corrected critical values for the unit root tests as given by, for instance, Davidson and MacKinnon (1993), because the cointegration equation has not to be tested but is given by the definition of the central parity in eq. (3). Conventional augmented Dickey Fuller and Phillips Perron unit root tests are used instead[21].

[21] In the classical Engle and Granger cointegration test the usual ADF and Phillips Perron test statistics cannot be applied to the residuals of the OLS estimation, because the OLS regression already gives an estimation of the cointegration equation which looks "most stationary" among all possible linear combinations. In our case, however the coefficient for CP_t is set to one by definition, so standard critical values are appropriate. For a discussion of this topic see Dickey et al. (1991), p. 69.

TABLE 9. Unit root tests for the deviation from central parity[1]

	CZK	HUF	PLZ[5]	SKK
	1/1994-2/1996	1/1994-12/1996	5/1995-2/1998	1/1994-12/1996
ADF[2]	-5.62***	-3.09***	-1.97**	-1.87*
PP[3]	-18.81***	-4.37***	-2.07**	-2.76***
	3/1996-5/1997	1/1997-12/1999	2/1998-12/1998	1/1997-9/1998
ADF	-0.59	-2.17**	-1.98**	-0.52 (-3.71***)[4]
PP	-0.86	-2.34**	-2.24**	-1.27 (-5.53***)[4]
		1/2000-5/2001	1/1999-4/2000	
ADF		-4.26***	-2.34**	
PP		-4.63***	-2.06**	
		5/2001-9/2001		
ADF		-2.30**		
PP		-2.89***		
		10/2001-10/2002		
ADF		-1.71*		
PP		-1.43		

[1] No central parity available for the officially floating Slovenian tolar and the Romanian leu.
[2] ADF: Augmented Dickey Fuller test against null hypothesis of unit root.
[3] PP: Phillips Perron test against null hypothesis of unit root.
[4] ADF and PP test statistics when a shorter sample period is used.
[5] Data for 1/1994 through 12/1996 not available.

The results show that there are mainly two groups of exchange rates: The first group consists of the Hungarian forint and the Polish zloty. Both exchange rates show stationary error terms, except for Hungary's present exchange rate regime, for which there is no clear evidence. Considering these results it can be stated that both countries have been quite successful in managing their exchange rates and have achieved their exchange rate goals. In contrast, for the Czech and the Slovak koruna the exchange rate regime was working only during the first period, whereas they were both not able to hold the exchange rate stable within the announced band after widening it. The case of the Slovak koruna is somehow special, because during the second subsample, when the band was ±7 per cent, the null of a unit root is soundly rejected when the

data for approximately the last 6 month are dropped. It therefore follows that the NBS was able to hold the exchange rate stable for about nine months after widening the band, but since early 1998 the exchange rate got more and more unstable and forced the NBS to switch to a managed float. In contrast the Czech koruna immediately lost its stability against the central parity after the exchange rate target got weaker in 1996 and consequently the CNB switched to a managed float after a comparatively short time: The widened band was in use for only 14 months.

As a second step we compare the officially announced weights of the basket currencies with the estimated ones. A quite general formulation (Frankel et al. 2001) of some alternative exchange rate regimes is given by the specification, which we refer to as the currency model:

$$s_t = \text{const.} + d \cdot t + \sum_{i=1}^{N} w_i \cdot s_{i,t} + \varepsilon_t \qquad (4)$$

where s_t is the currency under observation expressed in a numeraire, const. is a real number, d is the rate of crawl, t the time parameter and $s_{i,t}$ are currencies to which s_t is pegged. The currencies $s_{i,t}$ are expressed in the same numeraire as s_t and weighted in the basket with some weights w_i, which are nonnegative real numbers and sum up to one. As the numeraire we use the special drawing right (SDR) as proposed by Frankel and Wei (1993), although other numeraires would also be convenient[22]. For a deeper discussion of this question see Frankel et al. (2001).

It is obvious that eq. 1 nests a number of relevant alternative regimes. A simple peg implies d=0, N=1; a crawling peg d>0, N=1; a basket peg d=0, N>1 and a crawling basket d>0, N>1.

As proposed by Frankel et al. (2001) we apply the model to differences of log exchange rates and the model evolves to:

$$\Delta s_t = d + \sum_{i=1}^{N} w_i \cdot \Delta s_{i,t} + \varepsilon_t \qquad (4')$$

The setting of eq. (4) and eq. (4') allows performing various tests concerning the de facto exchange rate regime (H_0 denotes the null hypothesis, H_A the alternative):

[22] We reestimated equation (4') using the Japanese yen and the Swiss franc as a numeraire. This leads to some minor changes in the results. These are, however, not substantial and the general impression remains stable. The estimation output is available from the authors on request.

- First, one may generally test for a significant rate of crawl, that is

  $H_{1,0}$: $d = 0$ $_{\text{against}}$ $H_{1,A}$: $d \neq 0$ (test 1).

- Second, we test for any common movements between the currency under investigation and possible basket currencies:

  $H_{2,0}$: $w_i = 0$ for each single $i \in \{1,..,N\}$against $H_{2,A}$: $w_i \neq 0$ for any $i \in \{1,..,N\}$ (test 2).

- Third and fourth, we test whether the estimated weights are significantly different from the announced ones and sum up to one:

  $H_{3,0}$: $w_i = w_i^{official}$ for all $i \in \{1,..,N\}$against $H_{3,A}$: $w_i \neq w_i^{official}$ for any $i \in \{1,..,N\}$ (test 3)

  and

  $H_{4,0}$: $\sum_{i=1}^{N} w_i = 1$ against $H_{4,A}$: $\sum_{i=1}^{N} w_i \neq 1$ (test 4)

- Fifth, we test, whether the exchange rate is solely determined by the Deutsche mark, this test is then referred to as test 5, with H5,0: $w_{DEM}=1$, and all other weights are zero. Test 5 is performed, because a peg to the Deutsche mark (Euro) seems to be the most likely alternative to officially announced exchange rate regimes.

The first and the second test may be performed by using a simple t-test on the parameter estimates, the third and the fourth one are done by applying conventional Wald tests. The results for the tests 3-5 are given in a separate column in Tables 10a-10f. The third test is, of course, only performed if there have been any announcements.

The first and the second test may be performed by using a simple t-test on the parameter estimates and their results are simply given by the significance of the estimated coefficients.. The results for the tests 3-5, which are done by applying conventional Wald tests, are given in a separate column in Tables 10a-10f. The third test is, of course, only performed, if there have been any announcements at all. However, if the currency is (officially) pegged to the Deutsche mark (Euro), test 3, 4 and 5 are identical and only one result is given.

For the Czech koruna (Table 10a) the rate of crawl coefficient can not be distinguished from zero. This is in line with the fact that the CNB has never announced any rate of crawl. It is,

however, interesting that Wald tests indicate the weight w_{DEM} to be not significantly different from one, whereas the influence of the US Dollar seems to be at least close to zero for the whole period from 1994-5/1997. This is not in line with the officially announced basket, in which both, the Deutsche mark and the US dollar, were included. These results are confirmed by the tests. The announced weights are rejected on the one per cent level of significance for any particular subperiod. In contrast, the hypothesis that movements of the Czech koruna are solely determined by the Deutsche mark cannot be rejected. It is even more interesting that there is still a significant amount of common movements between the Deutsche mark and the Czech koruna after switching to a managed float, but also a slightly increased importance of the US dollar.

TABLE 10a. Estimation of the currency model for the CZK (in differences)

	d	SDR/DEM	SDR/USD	Wald tests[1]	DW	R^2	F
1/1994-2/1996	-0.0001 (0.194)	1.0106*** (0.000)	-0.0064 (0.880)	$H_{3,0}$: χ^2=651.432*** $H_{4,0}$: χ^2=0.003 $H_{5,0}$: χ^2=0.366	1.983	0.723	704.88***
3/1996-5/1997	0.0000 (0.882)	0.9857*** (0.000)	0.1246 (0.390)	$H_{3,0}$: χ^2=36.558*** $H_{4,0}$: χ^2=0.196 $H_{5,0}$: χ^2=2.027	2.054	0.291	62.10***
5/1997-10/2002	0.0000 (0.488)	0.9067*** (0.000)	0.0567 (0.300)	$H_{3,0}$: χ^2=0.209 $H_{5,0}$: χ^2=16.516***	2.093	0.406	470.29***

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.

The results for the Hungarian forint (Table 10b) are in line with the officially announced exchange rate policy: All the estimated coefficients cannot be significantly distinguished from those announced. This applies to the currencies included, their weights and the rate of crawl d, with exception of the period from 5/2001-9/2001 when the rate of crawl was indeed comparatively low, and the period from 10/2001 to 10/2002, where the relationship to the Euro gets much weaker.

TABLE 10b. Estimation of the currency model for the HUF (in differences)

	d	SDR/ECU	SDR/USD	Wald tests[1]	DW	R^2	F
1/1994-12/1996	-0.0008*** (0.000)	0.8164*** (0.000)	0.3539*** (0.000)	$H_{3,0}$: χ^2=1.633 $H_{4,0}$: χ^2=1.264 $H_{5,0}$: χ^2=85.788***	2.099	0.099	40.93***
		SDR/DEM					
1/1997-12/1999	-0.0004*** (0.000)	0.6800*** (0.000)	0.3114*** (0.000)	$H_{3,0}$: χ^2=1.244 $H_{4,0}$: χ^2=0.029 $H_{5,0}$: χ^2=457.551***	2.113	0.478	345.65***
		SDR/EUR					
1/2000-5/2001	-0.0001*** (0.003)	0.9878*** (0.000)	--	$H_{3\text{-}5,0}$: χ^2=2.634	2.137	0.981	17212***
5/2001-9/2001	0.0004 (0.581)	0.8275*** (0.000)	--	$H_{3\text{-}5,0}$: χ^2=1.344	1.681	0.226	30.93***
10/2001-10/2002	0.0003 (0.1954)	0.7768*** (0.000)	--	$H_{3\text{-}5,0}$: χ^2=14.979***	1.865	0.400	181.44***

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.

The Polish zloty (Table 10c) provides less clear results for the first years. This may be due to the more complicated structure of the basket. It includes highly correlated currencies like the Deutsche mark, the Swiss franc and especially the French franc. The poor results are in line with Frankel et al. (2001), who state that exchange rate regimes become more difficult to verify when the number of currencies in the basket is high and the problem of multicollinearity in the regression occurs. We therefore rely mainly on the results for the simpler basket from 1/1999 to 4/2000, which confirm the announced regime. Remarkably, the results do hardly differ for the period of the freely floating zloty. It still looks like being pegged to a basket of 60-65 per cent US dollar and 35-40 per cent Deutsche mark. However, the picture for the ROL is not that clear, because the R^2 is considerably low for the last period (0.06), which means that the variance of the error term is high, although the F statistic shows that the estimated relationship is still significant.

TABLE 10c. Estimation of the currency model for the PLZ (in differences)

	d	SDR/ USD	SDR/ DEM	SDR/ GBP	SDR/ FRF	SDR/ CHF		
1/1994-5/1995	-0.0009*** (0.000)	-0.0221 (0.788)	1.056*** (0.000)	0.1433** (0.017)	-0.0161 (0.888)	-0.1031 (0.194)	DW	2.038
							R^2	0.569
							F	88.85***
5/1995-2/1998	-0.0003** (0.018)	0.368*** (0.000)	0.195 (0.114)	0.0296 (0.463)	-0.052 (0.599)	0.1777*** (0.001)	DW	2.240
							R^2	0.069
							F	10.20***
2/1998-12/1998	-0.0002 (0.662)	0.4596*** (0.004)	2.1263 (0.701)	-0.299** (0.027)	-2.2837 (0.681)	0.578*** (0.001)	DW	2.208
							R^2	0.170
							F	8.49***
	d	**SDR/USD**	**SDR/EUR**		**Wald tests[1]**			
1/1999-4/2000	-0.0003 (0.4933)	0.7520*** (0.000)	0.4921*** (0.000)	--	$H_{3,0}$: χ^2=2.227 $H_{4,0}$: χ^2=1.793 $H_{5,0}$: χ^2=123,178***		DW	1.996
							R^2	0.132
							F	25.03***
4/2000-10/2002	0.0000 (0.9227)	0.6733*** (0.000)	0.3823*** (0.000)	--	$H_{4,0}$: χ^2=0.111 $H_{5,0}$: χ^2=378,421***		DW	1.773
							R^2	0.060
							F	20.46***

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.

Although no regime change has been officially announced for the Romanian leu the data provide evidence that there was a change in exchange rate policy. We therefore apply Quandt's likelihood ratio test (QLR) for the constancy of a regression relationship and find a structural break in April 1997[23]. This leads to Table 10d, which indeed shows different estimation results

[23] For this date the test statistic, which is defined as the maximum value of the F statistic in a recursively applied Chow breakpoint test, takes the value 43.61 being significant at any conventional level of significance, see Andrews (1993).

for both subperiods. Both periods have in common that there is a significant rate of crawl, which exceeds the rates for the other currencies in this investigation by a factor of about ten. For the first period, up to 3/1997, the ROL seems to follow a basket including both, the Deutsche mark and the US dollar. The picture becomes different when the second subperiod is considered. The Deutsche mark is no longer significant, whereas the influence of the US dollar has increased. The ROL behaves like being pegged to the US dollar. Due to the considerably low R^2, especially for the first period, the results have to be interpreted with some care. If the NBR has implicitly followed a peg to Deutsche mark and US dollar up to 1997 and to the US dollar from 1997 on, they may have used a wide band. This makes it difficult to distinguish the exchange rate behaviour from a float (Frankel et al., 2001).

TABLE 10d. Estimation of the currency model for the ROL (in differences)

	d	SDR/DEM	SDR/USD	Wald tests[1]	DW	R^2	F
1/1994-3/1997	-0.0023***	0.8100***	0.6040***	$H_{4,0}$: χ^2=2.439	1.747	0.040	16.75***
	(0.000)	(0.000)	(0.000)	$H_{5,0}$: χ^2=77.330***			
	d	**SDR/EUR**	**SDR/USD**	**Wald tests[1]**	**DW**	**R^2**	**F**
4/1997-10/2002	-0.0011***	0.0259	0.8085***	$H_{4,0}$: χ^2=2.926*	1.833	0.129	102.34***
	(0.000)	(0.5411)	(0.000)	$H_{5,0}$: χ^2=1446.34***			

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.

The results for the Slovenian tolar (Table 10e) are most interesting. Although the exchange rate policy has been classified as managed float all the time, the results strongly indicate some form of peg. First, the rate of crawl coefficient d is significant for both periods (1/1994-12/1998 and 1/1999-10/2002). Second, any movements of the tolar are almost solely explained by movements of the Deutsche mark (up to 1998) respective the Euro (1999-2002). The values of the R^2 and F statistic are very high, so we conclude that the BoS de facto followed a crawling peg against the Deutsche mark.

TABLE 10e. Estimation of the currency model for the SIT (in differences)

	d	SDR/DEM	SDR/USD	Wald tests[1]	DW	R^2	F
1/1994-12/1998	-0.0002*** (0.000)	0.9937*** (0.000)	-0.0061 (0.1549)	$H_{4,0}$: χ^2=2.399 $H_{5,0}$: χ^2=2.423	0.754[2]	0.989	53612***
	d	**SDR/EUR**	**SDR/USD**	**Wald tests[1]**	**DW**	**R^2**	**F**
1/1999-10/2002	-0.0002*** (0.001)	0.9765*** (0.000)	0.0033 (0.906)	$H_{4,0}$: χ^2=0.254 $H_{5,0}$: χ^2=3.835	2.832[2]	0.861	2999***

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.
[2] The results do not substantially differ when an AR(1) error term is introduced which eliminates the autocorrelation.

TABLE 10f. Estimation of the currency model for the SKK (in differences)

	d	SDR/DEM	SDR/USD	Wald tests[1]	DW	R^2	F
1/1994-12/1996	-0.0001 (0.352)	1.0035*** (0.000)	-0.0070 (0.875)	$H_{3,0}$: χ^2=0.002 $H_{4,0}$: χ^2=775.63*** $H_{5,0}$: χ^2=0.132	1.964	0.641	666.38***
1/1997-9/1998	-0.0000 (0.828)	1.0104*** (0.000)	0.0079 (0.902)	$H_{3,0}$: χ^2=0.041 $H_{4,0}$: χ^2=229.87*** $H_{5,0}$: χ^2=0.050	1.904	0.549	264.86***
	d	**SDR/EUR**	**SDR/USD**	**Wald tests[1]**	**DW**	**R^2**	**F**
10/1998-10/2002	-0.0000 (0.767)	0.9155*** (0.000)	0.0392 (0.439)	$H_{4,0}$: χ^2=0.394 $H_{5,0}$: χ^2=16.137***	1.4372[2]	0.560	662.29***

[1] Wald tests as described above. The χ^2 version of the Wald tests is used.
$H_{3,0}$: null hypothesis that the de facto weights equal the announced ones (only if there are any announced weights).
$H_{4,0:}$ null hypothesis that the weights sum up to one.
$H_{5,0:}$ null hypothesis that the w_{DEM}=1 and all other weights are zero.
Asterisks refer to level of significance: ***: ten per cent, **: five per cent, ***: one per cent.
[2] The results do not substantially differ when an AR(1) error term is introduced which eliminates the autocorrelation.

The Slovak koruna (results in Table 10f) again shows a behaviour which is very close to that of the Czech koruna. Officially pegged to a basket of Deutsche mark and US dollar its movements are mainly explained by the Deutsche mark. This is confirmed by tests: The

announced weights are rejected at the one per cent level, whereas the hypothesis that the weight of the Deutsche mark is one, whereas the US dollar is not included in the basket cannot be rejected at any level of significance. Even when the CNB had switched to a managed float, the koruna behaves in a way that is very similar to the Euro, although the hypothesis that it is solely determined by the Euro is rejected.

4. Conclusions

The six Central and Eastern European countries being have investigated during the period 1994 to 2002, have officially chosen different ways of stabilizing prices and exchange rates on their way to EU accession. In the early stage fixed exchange rates to a basket of currencies have dominated. While the Czech and Slovak Republic chose horizontal bands, Hungary and Poland had crawling peg/ band regimes. However, Slovenia and Romania claimed to have had managed floating exchange rate regimes during the entire sample period. The other countries subsequently moved to more flexible arrangements and mostly introduced a form of inflation targeting as the new nominal anchor.

Our research focuses on the question to which extent these countries have actually followed the nominal anchors which they have officially declared to have. Our first approach looks at the evidence of inflation and monetary targeting in these countries and gives a very mixed picture. Inflation targets quite often have not been achieved. Not hitting the target was usually explained by external factors which were beyond the reach of the central bank. The authorities also used this explanation when they targeted core inflation, which should diminish the influence of these factors. Monetary targeting in Slovenia was quite successful, though it should be kept in mind, that the BoS used very wide bands and thereby reduced the possibility of not meeting the target. Additionally, the financial system was still underdeveloped and the capital market opened comparatively late. These factors may have facilitated monetary targeting in the early stage.

We then investigated whether these countries have had an implicit exchange rate target: they may have had an implicit target even after they moved to floating exchange rates, or they may have actually preferred one currency during the period in which they targeted a basket of

currencies. We started with static volatility measures and frequency distributions. The evidence points at some implicit exchange rate targeting, especially in Slovenia, despite the fact that it declared a managed floating regime over the entire sample period.

As a next step we estimated a GARCH model, in which we include exchange rate regime as dummies. For exchange rates against the D-Mark, the dummies mostly have a significant influence on the estimation whereas they are less important for exchange rates against the US dollar. This may serve as evidence that the US Dollar was less important even in the early stage when it was one of the official basket currencies. However, in the Czech Republic this finding is less clear.

Unit root tests have supported the presumption that the Czech and Slovak koruna were driven to officially floating regimes by market forces. Under different external circumstances the authorities may have held on to the peg for longer.

Finally we used regression analysis in order to detect the currencies to which these Central and Eastern European currencies have most likely been de facto pegged. For this purpose we follow the methodology of Frankel et. al. (2000). The results show that the forint and the zloty have matched their officially announced regime and that the tolar seems to follow a crawling peg to the D-Mark (Euro). The exchange rates of the Czech and Slovak koruna can be best explained by movements of the D-Mark during the period, when they had fixed exchange rates to a basket of the D-Mark *and* the US dollar, and there seems to be some evidence that they still implicitly pegged to the D-Mark (Euro) after they were officially floating. The Romanian leu instead has rather moved to an implicit Dollar peg over time.

Summing up, the existence of an implicit exchange rate regime seems to be most likely in case of Slovenia, whereas in Hungary and Poland, de facto exchange rate regimes followed their de jure regimes relatively closely. The Czech and Slovak Republic take an intermediate position, with some evidence of exchange rate targeting to the D-Mark/ Euro even after they switched to floating regimes, whereas Romania is special, because it seems to have moved to an implicit Dollar peg. The Slovenian success in implicitly targeting its exchange rate may not be too surprising. Slovenia has opened its capital account relatively late, thus sheltering its exchange rate from external shocks. Accordingly, one should be careful in advising implicit exchange rate targeting, as the external environment may limit the viability of this option.

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Appendix

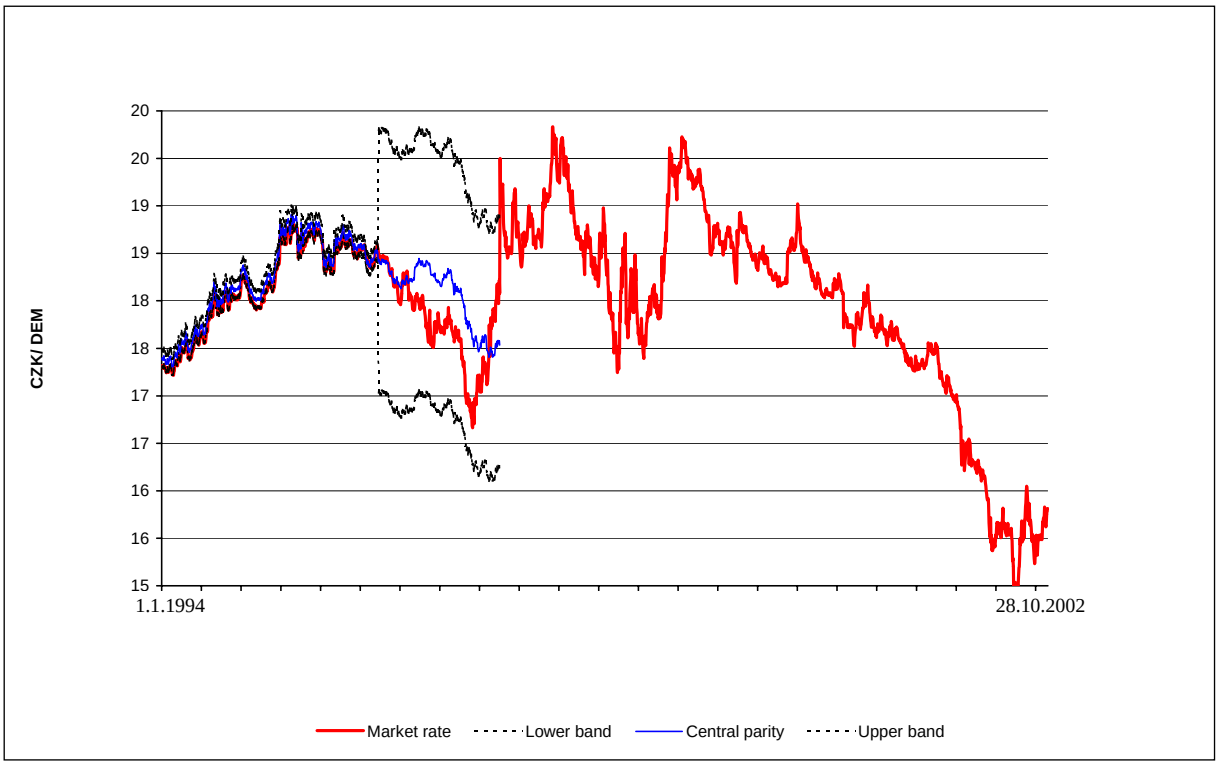
TABLE A1. Official exchange rate regimes since 1994

Czech Republic		Hungary		Poland		Slovenia/Romania		Slovak Republic	
Since 27.5.1997	Managed float	Since 1.10.2001	Peg to EUR (276,1 HUF/ EUR) Band: ±15%	Since 12.4.2000	Full floating	Since 1.1.1994	Managed floating	Since 1.10.1998	Managed floating
Since 1.3.1996	Band: ± 7,5% D2	Since 5/2001	Band: ±15% D4	Since 1.1.1999	45% USD, 55% EUR D4			Since 1.1.1997	Band: ± 7% D2
Since 1.1.1994	Basket peg 65% DEM, 35%USD Band: ± 0.5% D1	Since 1.1.2000	100% EUR D3	Since 25.2.1998	Band: ± 10% D3			Since 1.1.1994	Basket peg 60% DEM, 40%USD Band: ± 1.5% D1
		Since 1.1.1997	70% DEM, 30% USD D2	Since 16.5.1995	Band: ± 7% D2				
		Since 1.1.1994	Crawling peg* 70% Ecu, 30% USD Band: ±2.25% D1	Since 1.1.1994	Crawling peg 45% USD, 35% DEM, 10% GBP, 5% FF, 5% SF Band: ±1 % D1				

D1 to D4: Dummies used in the regressions of section 3.3.
Source: IMF, Exchange Rate Arrangements and Restrictions, various issues

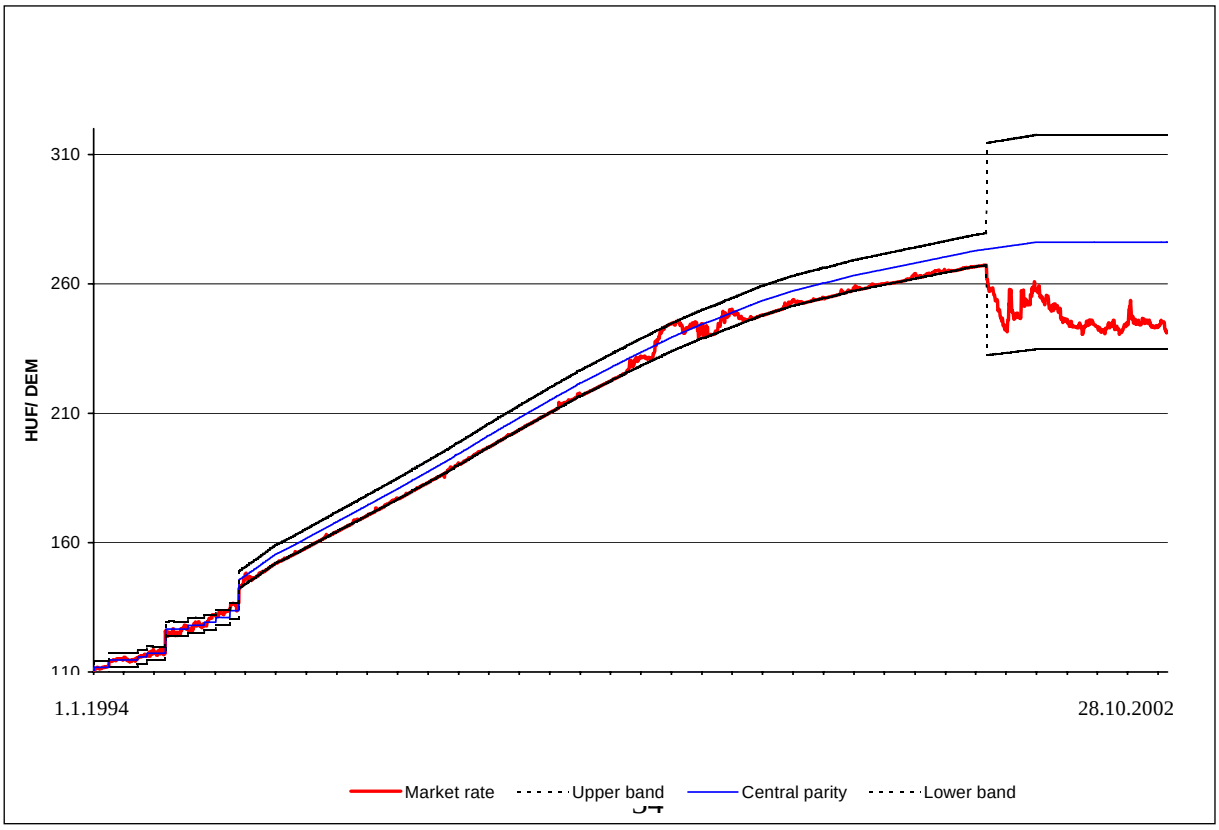
* Until 16.3.1995, the NBH devalued in discrete steps.

FIGURE A1. Exchange rate development of the Czech koruna, daily data, 1.1.1994-



28.10.2002

FIGURE A2. Exchange rate development of the Hungarian forint, daily data, 1.1.1994-



28.10.2002

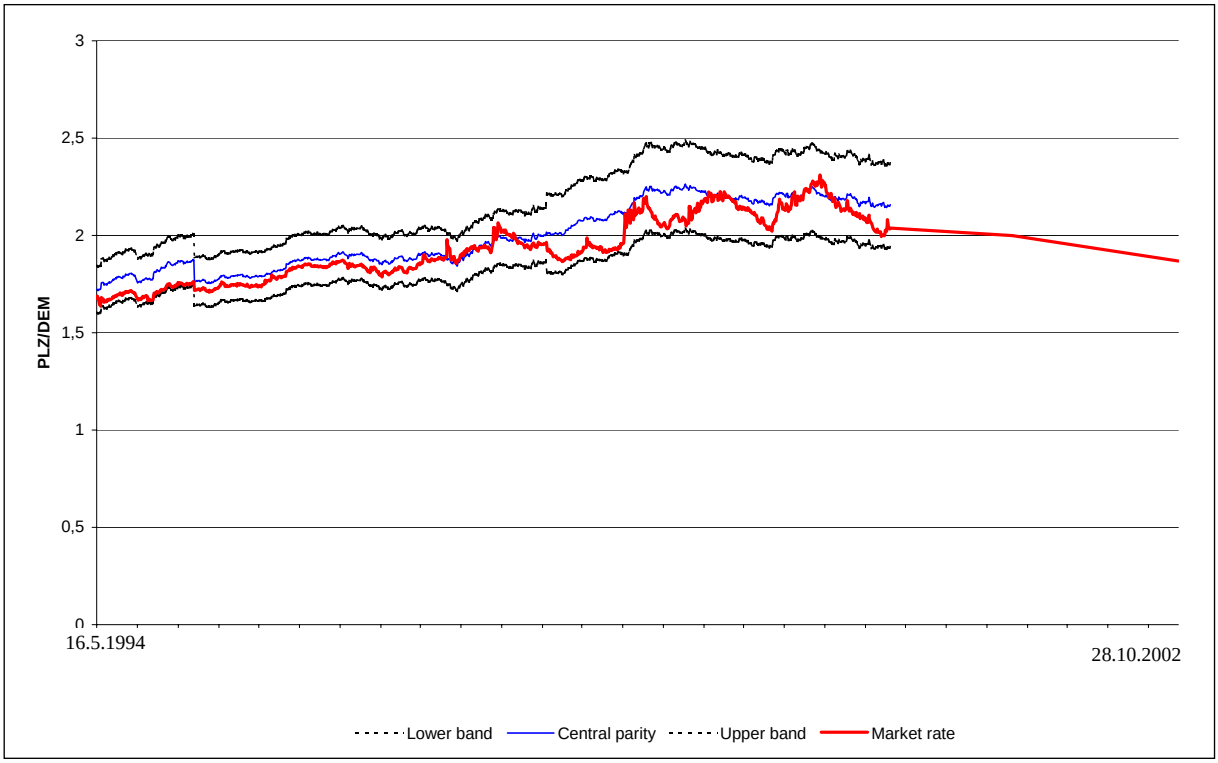


FIGURE A3. Exchange rate development of the Polish zloty, daily data, 16.5.1995-28.10.2002

FIGURE A4. Exchange rate development of the Romanian leu, daily data, 1.1.1994-28.10.2002

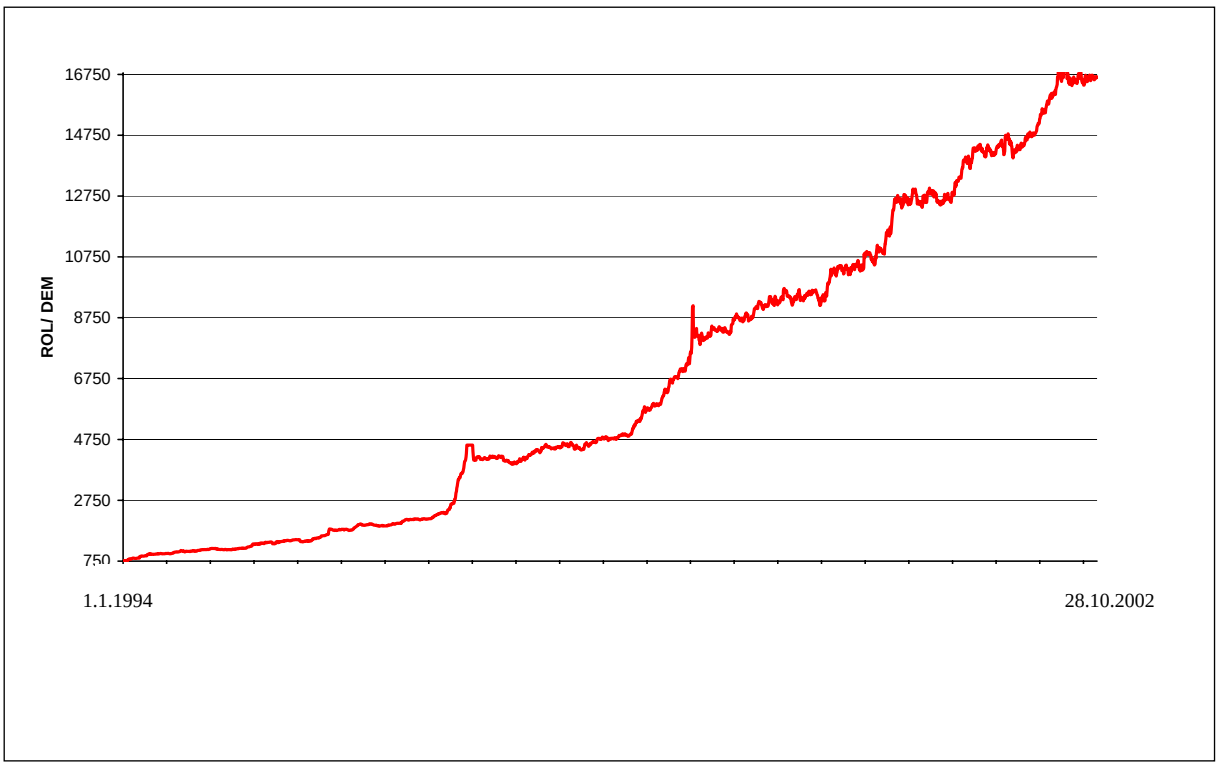
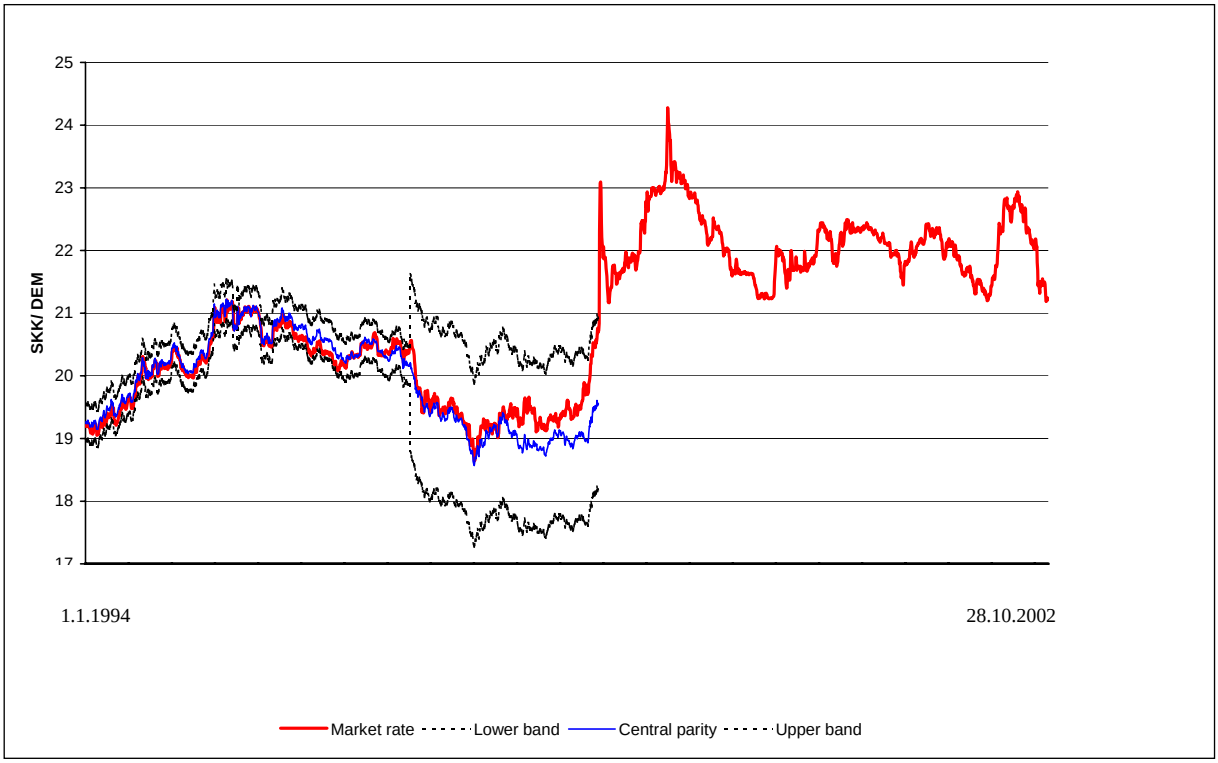

16750
14750
12750
10750
8750
6750
4750
2750
750
ROI/ DEM
1.1.1994
28.10.2002

FIGURE A5. Exchange rate development of the Slovak koruna, daily data, 1.1.1994-



28.10.2002

FIGURE A6. Exchange rate development of the Slovenian tolar, daily data, 1.1.1994-28.10.2002

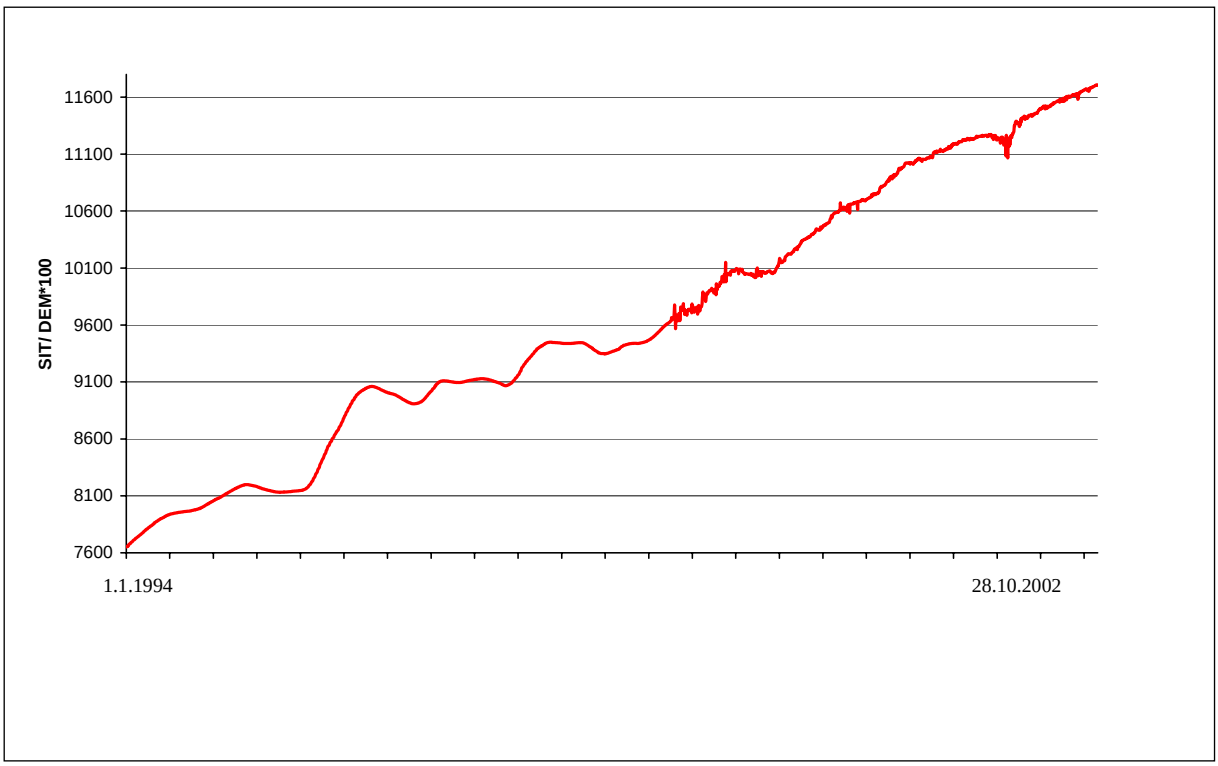
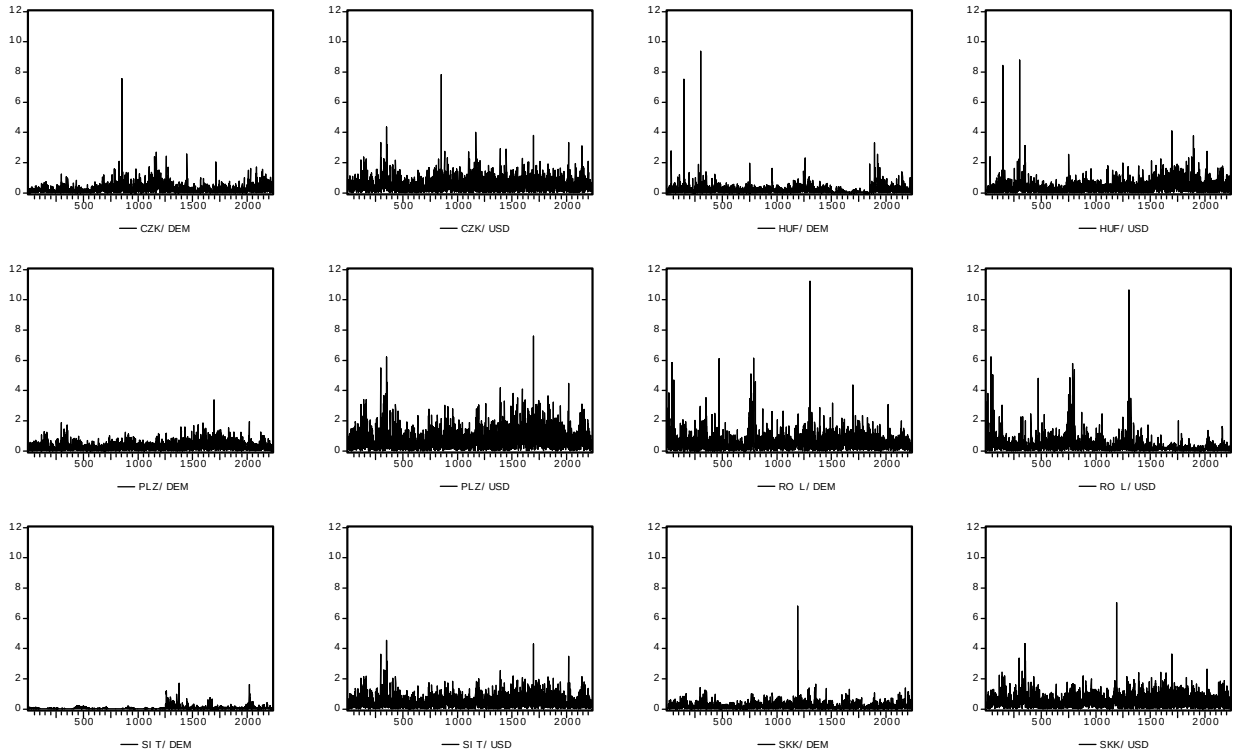

SIT/ DEM*100
11600
11100
10600
10100
9600
9100
8600
8100
7600
1.1.1994
28.10.2002

FIGURE A7. Absolute exchange rate returns, daily data, 1.1.1994-28.10.2002



DATA:

Monthly and quarterly data: IFS (unless otherwise stated)

Foreign exchange reserves (line 1d.d)

Base money (line 14)

Interest rate:
Money market rate (line 60b),
for Hungary: Treasury bill rate (line 60c)
for the Slovak Republic: Average lending rate (line 60p)
for Romania: Average refinancing rate of banks (National Bank of Romania), since 1999: Treasury bill rate (line 60c)

Daily exchange rate data:

Deutsche Bundesbank data base; for the Slovenian Tolar: BoS