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ABSTRACT

The Credibility of the Hungarian Exchange Rate Regime 1997-98*

This study intends to analyse the credibility of the Hungarian exchange rate regime preceding and during the Russian stock market crisis and devaluation (in 1998). Throughout the Paper the comparison with the similar regime in Poland is stressed. The basic tool applied is a measure of market imperfections, more precisely deviations from covered interest rate parity. The size, sign and dynamics of these deviations provide insight into the expectations of market participants. These in turn yield conclusions concerning the credibility and vulnerability of the regimes. Policy implications also follow.

JEL Classification: F31
Keywords: credibility, exchange rate regime, market liquidity and transition

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1. Introduction

The present paper intends to analyze the credibility of the crawling band exchange rate regime in Hungary for the period April 1997-October 1998. Special attention shall be payed to the effects of the Russian stock market crisis and devaluation on the expectations of investors concerning the Forint. Throughout the text a comparison with the similar regime in Poland is stressed, providing valuable insights.

The key idea of the paper is to have a close look at market imperfections, and see whether these can provide information about the expectations of market participants. Specifically, we shall test covered interest rate parity for both the Hungarian Forint and the Polish Zloty. Interestingly, it turns out that for extended time periods covered interest parity failed to hold for some of the markets to be considered. This fact shall be interpreted as a consequence of high market pressure on a relatively illiquid market. However, such market pressure reveals information about the expectations of the agents present in these markets. Hence we will be able to say something about exchange-rate expectations and thus the credibility of the regime.

Covered interest rate parity shall be tested on two Forint markets, one domestic and one London-based, and on one London-based Zloty market. The main finding is that the interest parity condition was generally holding on the Zloty, but failed to hold on the Forint markets, both preceding and during the Russian crisis. The breakdown of covered interest parity before the Russian crisis for the Forint shall be interpreted as evidence in favor of a highly credible exchange rate regime, with some appreciation expectations. In short, the argument is that only such expectations justify the market pressure necessary to imply the observed deviations.

During the Russian crisis, the (very high) deviations from covered interest parity on the two Forint markets have a different sign. This surprising fact indicates markedly different behavior on the domestic and foreign future markets. The deviation on the domestic market is explained by price manipulation; that on the foreign market by increased distrust in the regime. The tentative conclusion is that foreign investors questioned the credibility of the regime, but domestic investors did so only to a lesser extent.

Starting from the early nineties there has been a large amount of research devoted to empirically measuring credibility (see Garber-Svensson (1995) [9] for an overview). One popular approach is the drift-adjustment method (Bertola-Svensson (1993)[5]). The idea is to empirically decompose the interest rate differential into devaluation expectations and a risk premium. Often one deals with target zones; in that case the decomposition has three terms: realignment expectations, within-band depreciation and a risk premium. In order to identify realignment expectations from within-band depreciation expectations, a simple auxiliary model of the latter is estimated; usually it is assumed that within-band depreciation expectations is a linear function of lagged depreciation, lagged interest rates and possibly other variables. In our view this methodology is not fit for the purposes of the present study. The main reason is that domestic interest rates were an active

instrument of monetary policy in both countries, and thus it is not clear whether they are indeed determined by expectations, and not exogenous. Additionally, the Forint was during most of the time period we study at or very close to the strong side of the band. Estimating an auxiliary regression on this data is not likely to reveal too much about depreciation expectations; in particular it seems useless when applied to the period of the Russian crisis where exchange rate behavior was more volatile.

The rest of the paper is organized as follows: Section 2 reviews basic facts about the regimes in Hungary and Poland. Section 3 turns to measure these market imperfections by testing covered interest rate parity for the Forint and the Zloty. The results are interpreted in terms of market expectations and credibility in Section 4. Finally Section 5 concludes.

2. The Regimes

In the present section we briefly review some of the basic facts concerning the crawling band exchange rate regimes in Hungary and Poland during 1997-98. More thorough expositions may be found in Jakab-Szapáry (1998) [10] in the case of the former, and Darvas (1998) [7], pp. 157-181. for the latter. It is worth noting that the exchange rate regimes in both countries have changed since the period under investigation.

2.1. Forint

The Forint crawling band regime was introduced in March 1995 as part of a general stabilization package. During 1997-98, the central parity was determined by a (geometric) basket of currencies: 70% DM-30%USD. The bandwidth was plus-minus 2.25%. The rate of the crawl had been adjusted several times, basically in order to fit the path of disinflation. Each such adjustment was announced by the National Bank of Hungary (NBH) and the government several weeks, often months earlier. In practice, the NBH depreciates the central parity each trading day so that these changes add up to the rate of the crawl on a one-month basis. More formally, the (HUF/USD) central (NBH-quoted) exchange rate valid for the next trading day is calculated in the following manner:

$$\left(\frac{HUF}{USD}\right)_{t+1,central} = \left(\frac{HUF}{USD}\right)^{0.3}_{t,central} \left(\frac{HUF}{DM}\right)^{0.7}_{t,central} \left(\frac{DM}{USD}\right)^{0.7}_{t+1,market} (1 + crawl)$$

where t is measured in (trading-) days, $(HUF/currency)_{t,central}$ means the Forint-currency central exchange rate prevailing on day t (similarly for t+1), $(DM/USD)_{t+1,market}$ stands for the market DM-USD exchange rate on day $t+1$, finally $(1 + crawl)$ refers to the daily rate of crawl. A similar formula is valid for the (HUF/DM) central exchange rate:

$$\left(\frac{HUF}{DM}\right)_{t+1,central} = \left(\frac{HUF}{DM}\right)^{0.7}_{t,central} \left(\frac{HUF}{USD}\right)^{0.3}_{t,central} \left(\frac{USD}{DM}\right)^{0.3}_{t+1,market} (1 + crawl)\,.$$

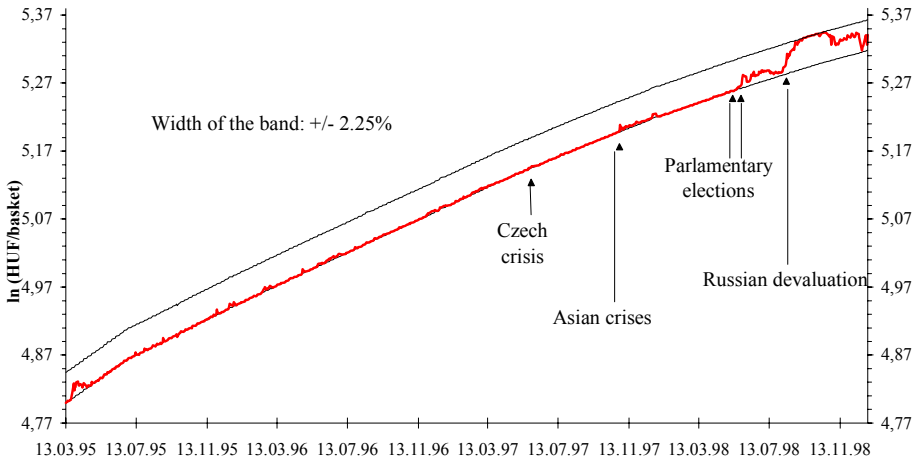

Figure 1: Hungarian Forint vs. basket 1995-98

The NBH is obliged to intervene at the sides of the band and has the right to deliver within-band intervention. The NBH intervenes in US dollars. Figure 1 plots the logarithm of the market exchange rate of the Forint against the geometric basket $((HUF/USD)^{0.3}\,(HUF/DM)^{0.7})$ as well as the central parity and the band. It is apparent that for most of the existence of the regime the exchange rate was 'stuck' to the strong side of the band. Substantial weakenings were corresponding to major political and/or economic events, as indicated in the Figure.

2.2. Zloty

The Zloty crawling exchange rate regime was introduced in October 1991. During 1997-98, the central parity was determined by a basket of five currencies: 45% USD, 35% DM, 10% GBP, 5% FFR, 5% CHF. The exact method of determining the central parity was not public. The bandwidth as well as the rate of the crawl have been changed several times during the existence of the regime. There have also been central parity realignments. These are all visible from Figure 2 which plots the logarithm of the market exchange rate of the Zloty against the (geometric) basket as well as the central parity and the band for the period March 1995-October 1998. Since the exact method of calculating the central parity is not available, estimations are necessary. This Figure is taken from Darvas (1998) [7], pp. 167. The calculations leading to the graph are explicitly explained there. We shall not rely on the exact value of the central parity in the sequel, so the Figure may be considered more as an illustration. It is well observable that for most of the time period the Zloty stayed within the stronger region of the band. Similarly to the case of the Forint pronounced weaknesses were associated with political/economic events.

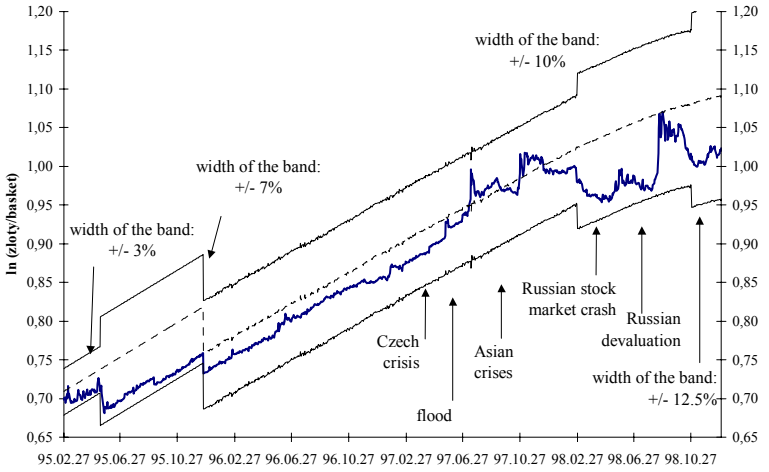

Figure 2: Polish Zloty vs. basket 1995-98

3. Covered Interest Parity: Data and Estimation

In the present section we make a short account on covered interest parity, describe the exchanges and data we consider, present the estimation results and a preliminary discussion. Interpretation and more thorough discussion are postponed until the next section.

Covered interest rate parity (CIP) is captured by the formula

$$\left(1 + r^*_{t,t+k}\right) \frac{f_{t,t+k}}{e_t} = 1 + r_{t,t+k} \tag{3.1}$$

where e_t stands for the spot, $f_{t,t+k}$ for the futures exchange rate at time t maturing at $t+k$ (each measured in domestic currency), and $r_{t,t+k}$, $r^*_{t,t+k}$ for the domestic and foreign risk-free interest rates respectively (for the same maturity). In the following we shall examine to what extent CIP prevails in Forint futures exchange markets. The straightforward method for testing CIP is to calculate the yields in domestic currency implied by investing in foreign risk-free securities and hedging exchange rate risk through futures operations, and then to compare these yields with domestic risk-free rates. In other words, to compute the left-hand side of the above formula and compare it with the right-hand side. This computation has been done for the Forint using futures prices quoted on the Budapest Commodity Exchange (BCE), and for both the Forint and the Zloty using data from the London Non-Deliverable Forward (NDF) market. Since these exchanges differ in several aspects, most importantly the maturity structure and the requirement of marking to market, it shall be convenient to handle them separately. We start by a more precise description of the differences.

The exchanges. There are two possible organized trading places to open futures positions in Forint: the Budapest Stock Exchange (BSE), and the Budapest Commodity

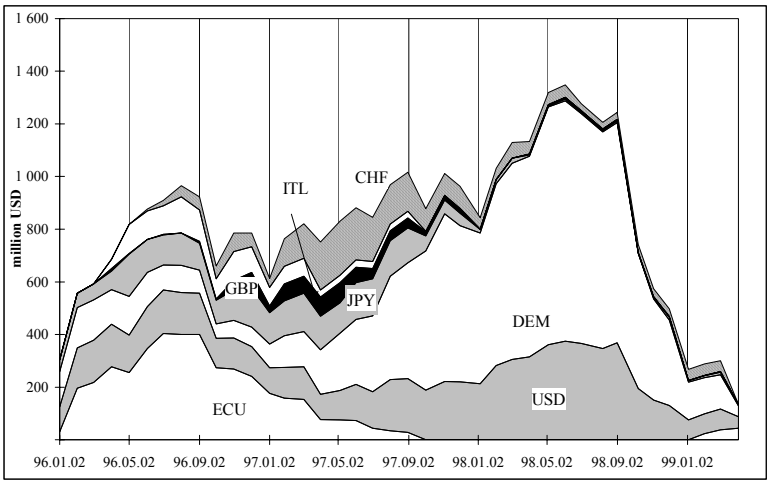

Figure 3: Volume of open contracts on the BCE 1995-1998

Exchange. The London NDF is an institutional forward market, trading both Forint and Zloty. There exist domestic Zloty futures markets in Poland, however no date has been available on their trading. One might also engage in domestic OTC forward transactions in either country, but again no statistical data is available on the volume or prices of this trading. As to the two domestic institutions in Hungary, the vast majority of currency futures transactions have taken place in the Budapest Commodity Exchange, which has consequently been chosen to be the subject of our study. On the BCE futures prices are quoted for selected expiration dates. The most liquid expiration dates are the quarterly ones; the corresponding futures prices are often referred to as the March, June, September and December futures exchange rates respectively (naturally the specification of the year is also necessary). For example on 11th July, 1997, one could have opened a futures position in Forint expiring on 17th September, 1997, a different one expiring on 17th December, 1997, or yet another one expiring on 17th March, 1998. Daily marking to the market is required, that is, margin accounts have to be refilled daily according to closing prices. Although several currencies are traded, most of the attention has focused on basket currencies (USD and DM), as it is plainly visible from Figure 3.

On the London NDF Forint (and Zloty) market there are forward prices quoted for (beyond others) a 3-month maturity each trading day. Thus, for example on the 11th July 1997 one could have opened a forward position in Forint (or Zloty) expiring 3-months from that day, that is, on the 11th October 1997. Daily marking to the market is not required. It is obvious that forward Forint prices of the NDF and the BCE on a typical trading day are not directly comparable. However, in the following we shall introduce more comparable measures, and indeed this comparison is going to be fruitful. We now turn to the issue of testing for CIP on the BCE.

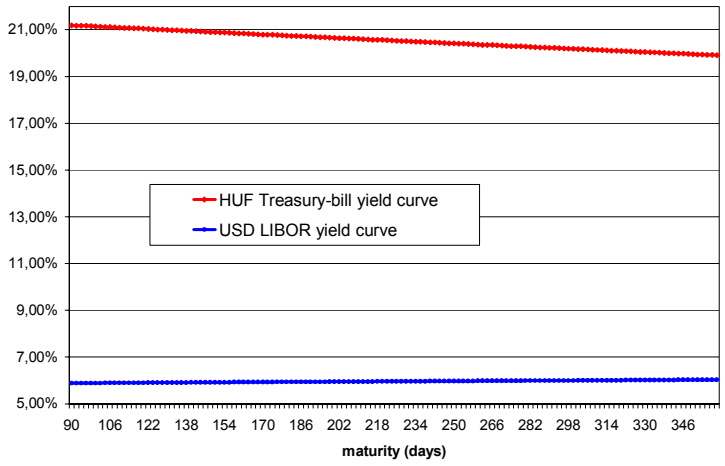

Figure 4: Hungarian T-bill and USD LIBOR yield curve estimations; 11. July 1997

The data. CIP has been tested for the USD-Forint market. Accordingly, as to the exchange rates, daily closing spot and futures USD prices of the Budapest Commodity Exchange have been used. The question of interest rates is, however, a bit trickier. Returning to our previous example, suppose we wish to test CIP on 11th July, 1997, for the December 1997 futures exchange rate. This means that we need domestic and foreign 157 day risk-free interest rates. Since such interest rates are not readily available, some estimations are necessary. For the domestic interest rates, daily (e.g. one on the 11th July 1997) zero-coupon yield curve estimations of the NBH constructed from Hungarian Treasury-bill yields have been applied (see Csajbók (1999) [4]). Although these curves seem to be very reliable for longer time horizons, such as three months or more, they lose their efficiency for short maturities[1]. Therefore we have chosen to test CIP each day for only those futures prices maturing at least 90 days later. As to the foreign interest rates, lack of similar estimates forced us to linearly interpolate the yield curve each day. This has been done using the 3-month, 6 month and 1 year LIBOR interest rates valid on that day. Since in contrast to the situation in Hungary these latter yield curves are almost flat, it is not likely that we lost much information. Figure 4 illustrates the case by plotting both the domestic and foreign yield curves prevailing on 11th July 1997.

Annualizing. It follows from what has been said that upon calculating an ('implied') domestic interest rate from the foreign interest rate and the spot and futures exchange rates (the left-hand side of (3.1)) , this value has to be compared to the domestic interest

[1]Since there are no official quotes for T-bill yields with (remaining) maturity less than 90 days, it is dificult to 'pin down' the short end of the yield curve estimation. Overnight inter-bank rates are too volatile; longer (e.g. one-month) inter-bank rates are not very reliable due to lack of liquidity in the market. See the reference for details.

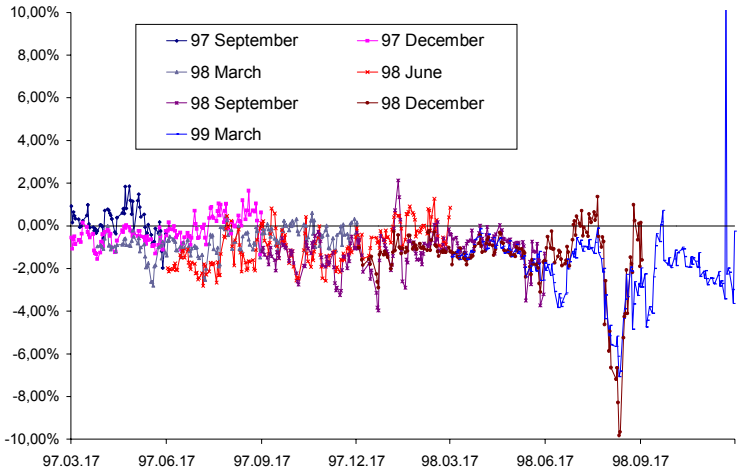

Figure 5: CIP deviations on the BCE 1997-98

rate valid that day and for the same maturity. Moreover, during the calculations the foreign interest rate needs to be transformed (geometrically) to the relevant time horizon (157 days in the previous example) so that it is measured consistently with the futures-spot exchange rate spread. The implied yield that follows should then be transformed back to a one-year basis. This is exactly what has been done. Figure 5 plots the daily difference (in the form of implied minus domestic) of the logarithm of annualized implied and domestic interest rates valid on that day for several maturities. Since it may be somewhat difficult to interpret so many graphs in one diagram we also plotted the average of daily deviations as well as the spot Forint within the band in Figure 6.

Discussion. It is apparent that the deviations for all maturities stayed between +3% and –3% except for one occasion during January 1998, and the periods 29th May-10th July 1998 and 13th August-29th September 1998. In the case of the latter period the deviation is exceptionally pronounced. These results strongly suggest that at least during certain time intervals CIP did not prevail on the BCE futures Forint market. Thus, before further investigating the data it seems reasonable to divide the time-frame into two parts, one ending on the 26th May 1998 (to be referred later as Interval I) the other starting the next trading day, 27th May 1998 (Interval II). We shall be arguing that CIP did prevail for the most part of Interval I (a 'tranquil period'), whereas it definitely and significantly failed during much of Interval II (a 'crisis period'). However, in order to be more explicit about this we need to survey possible explanations of the difference between domestic and implied interest rates.

The following table shows the averages and standard deviations of the plotted data for both time intervals as well as for the whole time-frame.

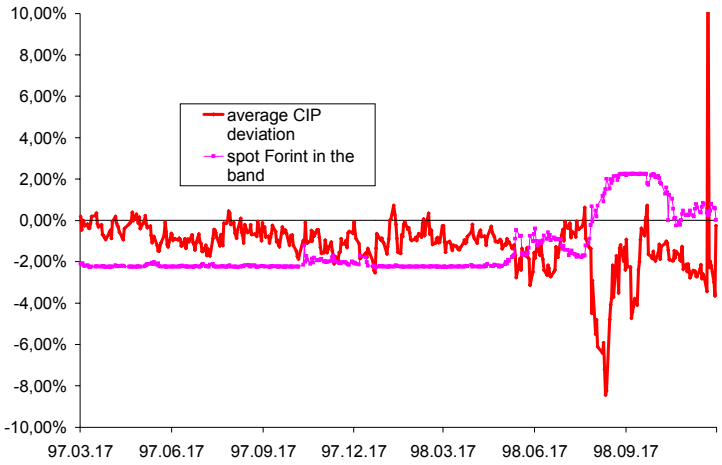

Figure 6: Average CIP deviation on the BCE and spot Forint within the band; 1997-98

	Interval I (17.03.97-26.05.98)	Interval II (27.05.98-16.12.98)	all (17.03.97-16.12.98)
average	-0.80%	-2.03%	-1.06%
standard deviation	0.82%	2.01%	1.28%

The averages shown capture a fact which is pretty obvious from simply looking at the graphs: namely that the deviations are typically of a negative sign. Indeed, only 13.39% of all deviations is greater then zero. Concentrating firstly on Interval I, what may cause an average deviation of –0.80%? We wish to set aside this question for a while, and further investigate it in the next section. Our reasons are twofold: firstly, the analysis of the London NDF market will provide valuable insights. Secondly, some of the explanations given will be related to market behavior, expectations and the credibility of the regime, and these issues are to be tackled in Section 5. So imagine for now that the average deviation is somehow taken care of, and turn to the problem of explaining the volatility of the plotted deviations, still focusing on Interval I.

One obvious reason is the role of transactions costs. It is well known that transactions costs provide a neutral band around the domestic interest rate within which no arbitrage is possible. These transactions costs arise when engaging in spot and futures currency transactions as well as when entering the domestic or foreign money market, i.e. buying or selling risk-free securities. During our procedure of annualizing all relevant data the noise stemming from transactions costs was transformed accordingly. It is at least unclear whether this transformation of costs may be justified on economic grounds. One might overcome the difficulty by transforming back the data to the original time horizon. However, other factors explaining the average deviation from CIP (see below) are more properly measured on a fixed time-horizon, e.g. one year. Upon transforming back the

data these factors would lose their exact meaning and would be equally difficult to handle. Thus we decided to keep all data measured on one fixed time-horizon (1 year), so that at least inter-day comparability is preserved.

It is still worth noting that Frenkel-Levich (1975) [8] estimated transactions costs between USD, GBP and DM 3-month interest arbitrage to be around 0.15%. On a one year basis this accounts for a spread around the domestic interest rate of plus-minus 0.6%. During Interval I such a band around the average deviation (=-0.80%) explains only 59.02% of the calculated data. However transactions costs in Hungary may well be higher. For example a (plus-minus) 1% transactions cost on a one-year basis explains 79.22% of the data during Interval I.

Furthermore, and this refers to the average deviation as well, data and measurement errors can have significant effects. We used yield curve estimations. All exchange rates applied were closing prices which may differ from daytime trading prices. As to the size and sign of these effects we have no information. However, the data for Interval I seem to be consistent, suggesting that CIP prevailed during most of Interval I, or even if it did not, the extent of failure was small. It is indeed unlikely that large unexploited profit opportunities existed for such a long time. Therefore it seems reasonable to use Interval I for comparison when analyzing Interval II, where significantly more turbulent behavior is observed.

We now turn to examine the data of Interval II. It seems apparent from Figure 6 that CIP deviations were correlated with the movements of the spot exchange rate within the band. Not much more is left to be said; the comparison with Interval I implies in a straightforward manner that CIP did fail during our second period, most notably during June and from mid-August until the end of September, with deviations sometimes as large as 10%. There is one day (8th December 1998) when CIP again definitely failed, but on this occasion the deviation has a positive sign. As to the June (parliamentary elections) and August-September (Russian crisis) periods there exists an explanation: during these periods of weak Forint daily closing futures prices (which determine margin accounts) were manipulated by brokers to avoid losses and possible default of their customers. This issue will be more thoroughly investigated in Section 5.2; the conclusion that CIP failed for much of Interval II suffices for now.

The London market. Next we shall be testing CIP on the London NDF Forint and Zloty market. This is a considerably easier issue since, as it has been pointed out, 3-month forward currency contracts are quoted each trading day. Therefore it is most easy to calculate the implied rates, no maturity-transformation is necessary. The time period to be considered is 5th January – 25th November 1998.

As to the data: the USD interest rates applied were daily closing quotes of 3-month LIBOR rates. The domestic interest rates used were 3-month inter-bank rates. The reason for choosing these latter rates is simple: for Poland, no daily data on Treasury bill yields was available. One might have applied inter-bank rates throughout the previous test (of the BCE) in order to be consistent, however there was no corresponding yield curve

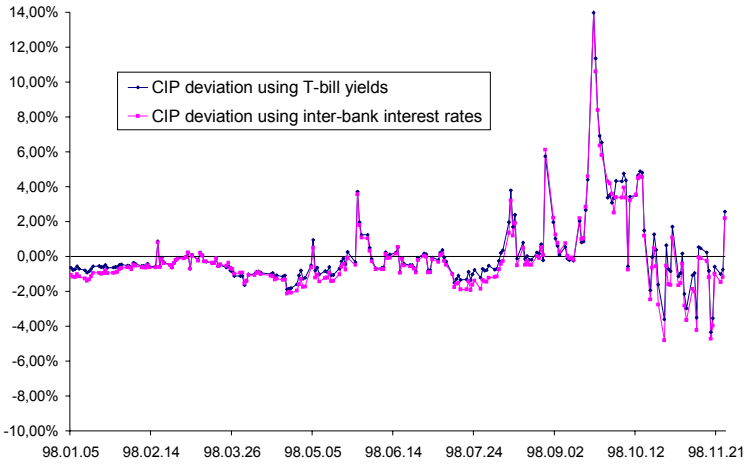

Figure 7: Forint CIP deviations on the NDF; 1998

estimate based on these rates. Thus there was a trade-off as to whether apply the available estimates at the price of some inconsistency, or stick to inter-bank-rates and (e.g.) linearly interpolate. We have chosen the former approach. Nevertheless all calculations to follow have also been delivered using T-bill yields (for the Forint) and all corresponding results are reported. It shall be apparent that the difference is indeed minor, suggesting that we have not lost much information, if any. In the case of the Zloty an average of the (log of) daily ask and bid interest rates, for the Forint daily closing BUBOR rates have been made use of. The spot and futures exchange rates were those quoted at the London NDF.

After computing the left and right side of our formula, that is the implied and domestic rates, we (geometrically) annualized the results from their 3-month time horizon, and calculated the difference between their logarithms. This difference (in the form of implied minus domestic) for the Forint and the Zloty is plotted on Figures 7 and 8 respectively. As to the Forint, it again seems plausible to divide the time-frame into two intervals separated by the 26th May 1998. Indeed, the deviation exhibits rather conservative behavior before, and some wild fluctuations appear after that day, the latter being most pronounced during August and September. It is also visible from the graphs that the difference upon applying Treasury-bill yields or BUBOR interest rates is not very significant relative to the size of the deviation, although results of the former approach are typically somewhat higher.

The following table reports the average and standard deviation of the plotted values (in the case of the Forint the results calculated using T-bill yields appear in parenthesis) for the sub-intervals as well as for the whole time frame for both currencies.

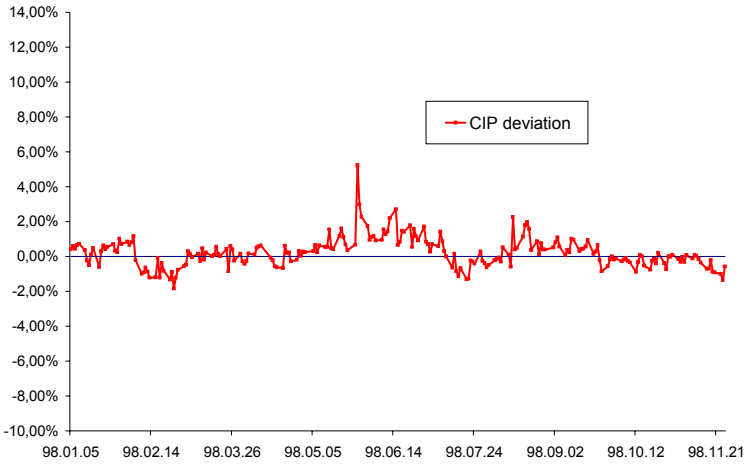

Figure 8: Zloty CIP deviations on the NDF; 1998

time frame	Interval I' (05.01.98-26.05.98)		Interval II' (05.01.98-25.11.98)		All (05.01.98-25.11.98)	
	Forint	Zloty	Forint	Zloty	Forint	Zloty
average	-0.82% (-0.64%)	0.08%	0.39% (0.70%)	0.32%	-0.73% (-0.53%)	0.22%
standard deviation	0.75% (0.68%)	0.65%	2.70% (2.61%)	0.96%	0.75% (0.68%)	0.85%

Note that the notation Interval I' (similarly Interval II') refers to a sub-period of Interval I (Interval II) studied earlier, since the examined time horizon is shorter now. However the day separating these intervals (26th May 1998) is the same in both cases.

As to the Forint the results for Interval I', a more tranquil period, are broadly consistent with those obtained for Interval I when concentrating on the BCE market. In contrast, during Interval II' the sign of the large deviations in August and September visible from the graphs is positive, whereas our earlier analysis of CIP on the BCE resulted in deviations of similar size but of opposite sign for Interval II. This fact is indeed striking, and later we shall be examining it more thoroughly. Here it suffices to conclude that CIP prevailed for most of Interval I' with only relatively small deviations, and definitely failed for much of Interval II', especially during the Russian crisis.

Turning to the case of the Zloty, two interesting issues arise. Firstly, the average deviation for Interval I' is almost nil, and for the whole period slightly positive, in sharp contrast with our results for the Forint in each exchange. This fact deserves further attention. Secondly, the data for Interval II' are only slightly more volatile than those for Interval I'. One might deduce that apart from a few occasions CIP prevailed for the

whole time frame.

We are now left at explaining the observed differences between the behavior of the Forint and Zloty futures rates, as well as the disparity in the sign of the deviations for the Forint NDF and BCE markets. This is the subject of the next section.

4. Credibility: Discussion

We start this section by more closely examining some of the puzzles revealed in the previous one. Conclusions about market expectations are to emerge from the study. The puzzles under consideration are:

a, The difference between the averages of CIP deviations for the Forint and the Zloty during the tranquil period.

b, The difference between the behavior of these deviations for the second time interval, with much more turbulent behavior exhibited by the Forint.

c, The different sign of deviations for the Forint on the two markets during August-September 1998.

We shall proceed in this order.

4.1. Market Behavior During Tranquil Times

In this subsection we shall focus on the tranquil period. The result that Forint produced typically negative deviations during that time seems to be robust in the sense that it does not depend on the market studied. However, such consistency may stem from a consistent misspecification of interest rates. Observe that the foreign rates applied were numerically the same in each case, and as to the domestic rate inter-bank quotes have been used for the London NDF market for both countries. (With T-bill rates for Hungary producing qualitatively the same result). Thus if capital markets are perfect, any such misspecification must be caused by some difference between the structure or riskiness of inter-bank rates in the two countries. This explanation seems to be unlikely. It is also possible that there is a country specific default risk attached to the pricing of forward contracts. We do not believe that there was such a difference between the countries under consideration in terms of default risk.

If the assumption of perfect capital markets is relaxed, then market imperfections such as liquidity effects may also lead to consistent mispricing. Indeed, suppose that the demand and supply elasticities on the market are less than infinite; in other words, that price is not independent of the trading volume. In such a situation, significant one-sided market pressure may result in systematic deviations from equilibrium. Assume that typical actors on the exchange take long positions in futures Forint against basket currencies, and that their demand is high. This assumption has some relevance as to the BCE futures market. The finiteness of elasticities implies that the price of futures

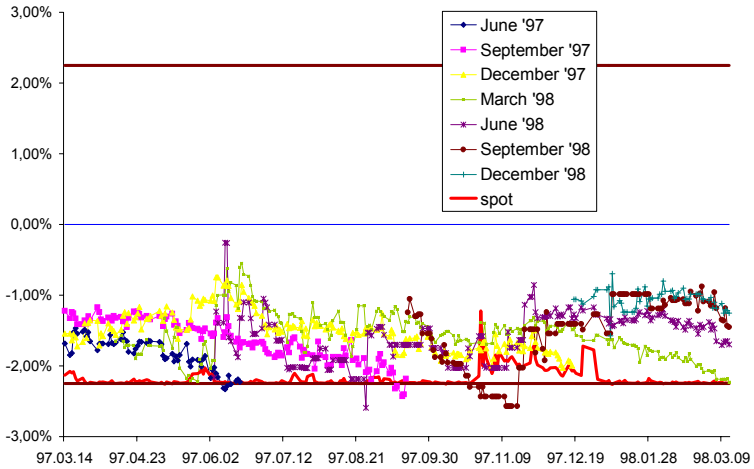

Figure 9: Futures BCE basket exchenge rates within their projected band and spot rate within band; March 1997- March 1998

Forint measured in USD increases ($f_{t,t+k}$ decreases). Therefore the implied interest rate, captured by the left hand side of our formula for CIP decreases, so the plotted deviation (implied minus domestic) decreases. If this hypothesis is responsible for a proportion of the average negative deviation, one conclusion is apparent: such market behavior was less typical for the Zloty futures exchange.

In this situation the interest rates applied may also be incorrect in another way. Suppose again that a typical actor in the futures market is small, and takes a long position in Forint against basket currencies (with banks taking the corresponding short position). Had the futures market not existed, the composite transaction required for her to duplicate this position would have two additional costs: One is that being small, she would only be able to borrow basket currencies at higher than LIBOR interest rates, the other is that investing in treasury bills also has a lump-sum transaction cost which may be relevant on that scale. Moreover, a proportion of the average deviation may simply be bankers' profit: they take the short position in Forint and hedge it through CIP, arbitraging the spread between implied and T-bill yields.

The time is right now to more thoroughly examine typical market behavior in the BCE Forint futures exchange. First of all, the assumption of small actors going long in Forint is consistent with our results. In the following we shall see that this assumption is also supported by other reasons. We shall argue that a number of small domestic investors had such exchange rate expectations that implied long Forint positions to be a very favorable investment.

It has been observed that until May 1998 the Forint stayed at the strong side of the band for most of the existence of the regime. Construct now a basket of futures exchange

rates (for the same maturity) according to the basket of the Forint, and call the resulting price process measured in Forint the futures basket exchange rate. It turns out (see Figures 9-10), that the BCE futures basket exchange rate was almost always weaker then the strong side of the projected band. This latter term here means the band expected to be valid on the date of maturity if the crawling regime prevails and the crawl is determined by NBH announcements up to now. More formally (in the logarithmic sense):

$$(c_t + w_{t,t+k}) \pm b \tag{4.2}$$

is the projected band, where c_t stands for the central parity at time t, $w_{t,t+k}$ for the projected crawl valid for the time horizon $[t, t+k]$ and b for the bandwidth. It is plausible that at least part of the market, based on previous experiences, expected the Forint to be at the strong side of the band on the date of maturity. Should this expectation turn out to be true, opening a long Forint futures position against properly weighted basket currencies is profitable: the futures basket exchange rate in Forint is weaker now than the strong side will be on the day of maturity, so the futures rate has to strengthen, and this implies positive income for holders of long Forint positions. And indeed, all that has been said was common wisdom in the BCE market as early as 1996 (see Darvas (1996) [6]). Accordingly, a growing number of speculators were opening long positions in Forint to harvest the gains. In the sequel we shall use the term 'basket speculators' to refer to them. A look at Figure 3 may further illustrate that. One may expect that if the majority of the participants in the futures market are there to hedge currency risks (e.g. companies engaged in export and import), then the amount of open contracts increases if the exchange rate is more volatile, and decreases if it constantly stays at the strong side of the band. However the Figure shows contrary tendencies: the volume of trading in the futures market was almost constantly increasing until late summer 1998, and dramatically fell after September. Moreover most of the trading concentrated on USD and DM with larger emphasis on the latter one, resembling the weights of the basket. It seems that the more volatile exchange rate behavior experienced since the Russian crisis cut out speculation, which was responsible for much of the trading. The monthly average of the volume of open contracts (in all traded currencies) on the BCE measured in USD for the five months following 1st October 1998 is less then 30% of the similar average for the five months before that day.

In this situation, banks going short in futures Forint must have been aware that should the exchange rate remain on the strong side of the band, their marginal positions are to gradually worsen. So a continuous refillment is necessary, and to the extent this refillment is to be delivered in cash it may have additional costs. If these costs are taken into consideration upon pricing then somewhat stronger futures Forint prices result in, pushing the implied interest rates as well as the (plotted) deviations downward.

In our view at least on the BCE futures market the average deviations are to a large extent explained by the consequences of market pressure. However, we do not know whether this behavior was also typical on the London NDF Forint market. Even so, the

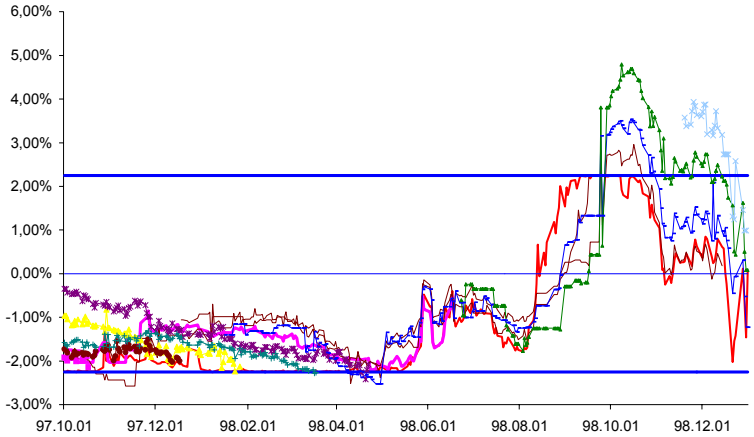

Figure 10: Futures BCE basket exchange rates within their projected band and spot rate within band October 1997-December 1998

two Forint exchanges may well be interlinked, and systematic deviations on one market may spread to the other one. The basic channel is arbitrage: there are trading days when certain prices on the two exchanges are directly comparable. It is also possible that some larger actors (e.g. Citibank, Deutsche Bank, Creditanstalt etc.) are present on both markets and they use the same valuation method on either exchange. The fact that this behavior is atypical of the Zloty futures market may be explained in the following way: Firstly, the exchange rate of the Zloty was more volatile within its band than that of the Forint, therefore profit opportunities were somewhat riskier. Secondly, the basket for the Zloty consists of five currencies, so it is technically more difficult and also more costly to construct a basket futures rate.

Now, the behavior of market participants on the BCE outlined so far leads us in a straightforward manner to the conclusion that the regime was credible. Indeed, it has been seen that the exchange rate was expected to remain on the strong side of the band. Even more, this expectation was the source of extensive speculation in favor of the Forint, thereby reinforcing the strength of the currency. We are dealing with a typical example of self-fulfilling expectations. Note that we are not questioning whether these expectations were fundamentally unjustified; however their self-strengthening nature is apparent.

Still focusing on the tranquil period, we wish to push our point on the credibility of the regime somewhat further. To do so, we need a convenient measure of the profit opportunities incorporated in basket speculation. Modulo the observed deviations from CIP, the interest rate differential minus projected crawl is a perfect nominee. Furthermore it also measures the profits international investors realize on LIBOR rates when they invest in Hungarian T-bills instead. Therefore, for each trading day we calculated (the log of)

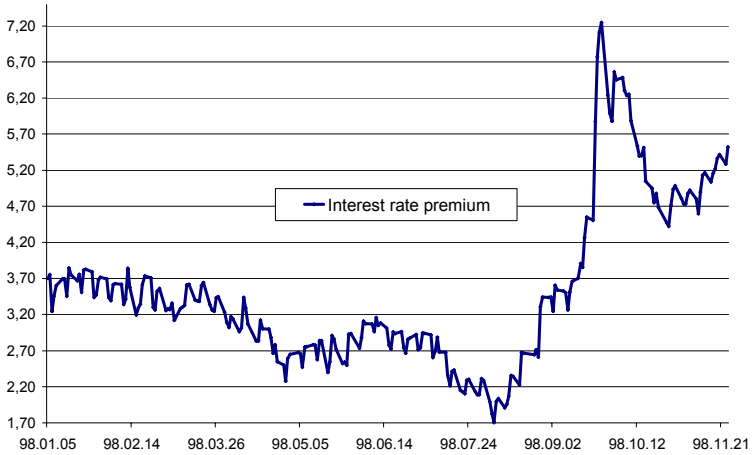

Figure 11: Interest rate premium in Hungary 1998

a geometrically weighted basket interest rate (i^*) from 3-month USD and DM LIBOR interest rates, and subtracted from it the accordingly transformed 3-month domestic T-bill yield (i) as well as the projected crawl valid for the 90 days under consideration (dw_t/dt). This latter term is based on NBH announcements on the crawl. The results have then been annualized and are shown in Figure 11. In the sequel we shall address such a value as the '3-month interest rate premium' valid for that day. Although the curve in the figure is rather volatile, it is obvious that during the period January-late April 1998 the plotted interest rate premium was gradually decreasing, from 3.75% in early January to 2.5% in late April. So we might conclude that the profit opportunities significantly decreased.

However, observe from Figure 3 that the amount of open futures contracts in basket currencies on the BCE was almost constantly increasing from early 1997 until August 1998 (there is a slight decline associated with the Asian crisis). This tendency was exceptionally pronounced in January-April 1998. As Figure 12 shows, during that latter period there was an equally rapid increase in the volume of government securities owned by non-resident investors. Either phenomenon may be explained by (re)gaining investor trust after the Asian crisis, both on behalf of domestic and foreign investors. They can not be explained, as we have seen, by increased profit opportunities. Quite the contrary, it is possible that growing interest in Hungarian Treasury-bills pushed their prices upward, thereby reducing their yields. And there is one more degree of freedom which we have not taken care of so far: the width of the band. Indeed, it has been implicitly assumed that the bandwidth was expected to remain constant. However, if the market expected a widening, and Forint to strengthen accordingly to the strong side of the new band, then increased speculation in favor of the currency is justified, even though it is not visible

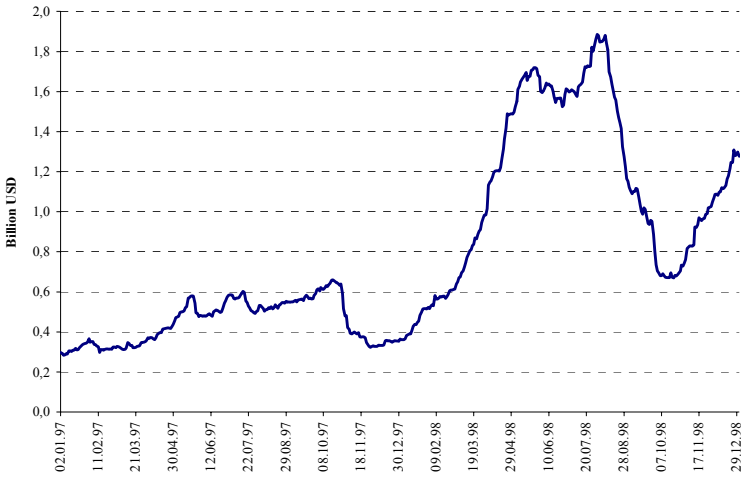

Figure 12: Non-resident holdings of Hungarian government securities 1998

from our diagram. Such an expectation may be based upon the experience in Poland: the band of the Zloty was widened from plus-minus 7% to plus-minus 10% on 25th February 1998.

Also, having another look at Figures 1, 11 and 12 demonstrates a similar synchronous movement during mid-July. Following the above reasoning one might deduce that after the parliamentary elections band-widening expectations again played a role in market decisions. Indeed, the hypothesis that these expectations were the driving force behind part of the increased speculation during the second quarter of 1998 is not contradictory to some articles appearing in daily economic newspapers that time (e.g. Napi Gazdaság, 21. July 1998).

Band-widening expectations can also affect the decisions of export-import companies. Fears of an appreciating Forint might have led such companies to hedge currency-risk through the futures or forward market even if they had not done so earlier, having predicted Forint to remain at the strong side of the (unchanged) band. In this case increased demand for long Forint positions again pushes the CIP deviations in the desired direction. We feel that this explanation may have some relevance as to the London NDF market.

Summing up, our analysis of the average deviations from CIP in the Forint and Zloty futures markets led to two conclusions: the Hungarian crawling band was extremely credible during the tranquil period in the sense that there were no fears of depreciation. On the other hand, there were some appreciation expectations. We now turn to the other puzzles.

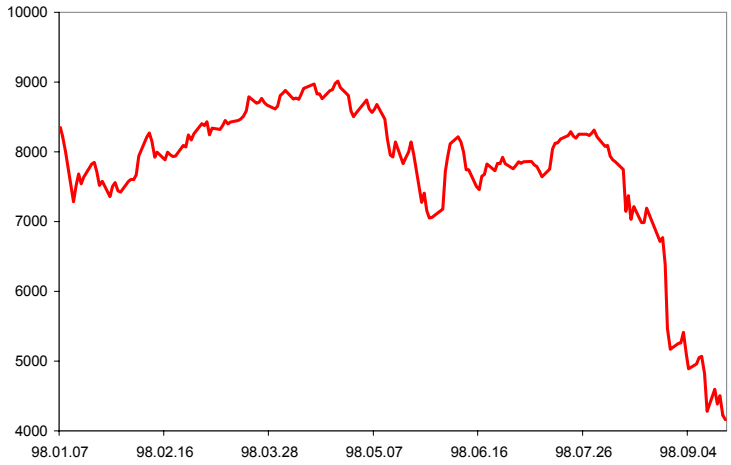

Figure 13: Budapest Stock Index 1998

4.2. Contagion in Hungary

As to *b*, there is a straightforward answer. During the Russian crisis the credibility of the Forint exchange rate regime was questioned; that of the Zloty was not, or only to a much lesser extent. The latter statement is easier to justify: the Zloty exchange rate never even reached the weak side of its (wide compared to the Forint) band, even though within-band depreciation was more then 10% during the crisis days. In contrast, in Hungary the Forint did reach the weak side of its much narrower band and did stay there for quite a while. However we wish to produce some sounder reasons indicating that the credibility of the regime was less pronounced than during the tranquil period. To do so, some measurement of credibility is necessary. Moreover, a closer look at the economic events associated with exchange rate behavior during that period in Hungary will also prove to be helpful. It will turn out, not very surprisingly, that puzzle *c*, i.e. the failure of CIP is also closely related to this issue. We begin with a short summary of the events.

During the period of parliamentary elections (June 1998), the Forint slightly depreciated within the band. This was followed by an appreciation, but the exchange rate did not return to the strong side of the band. (See Figure 1).

The main reason behind the continued weakness of the Forint after the elections must have been the behavior of international capital markets. It was the period of the Russian stock market crisis and devaluation (on 17th August). There was extreme financial pressure on the Russian exchange rate regime, with interest rates peaking at astronomical heights. All stock markets in the region were bearish, indicating investor distrust, indeed, panic. (For the Warsaw and Budapest exchanges see Figures 13-14.) BUX, the Budapest Stock Exchange Index lost about 40% of its late July value (in less then a month!). Strains also spread to exchange rates, eventually leading to the devaluation

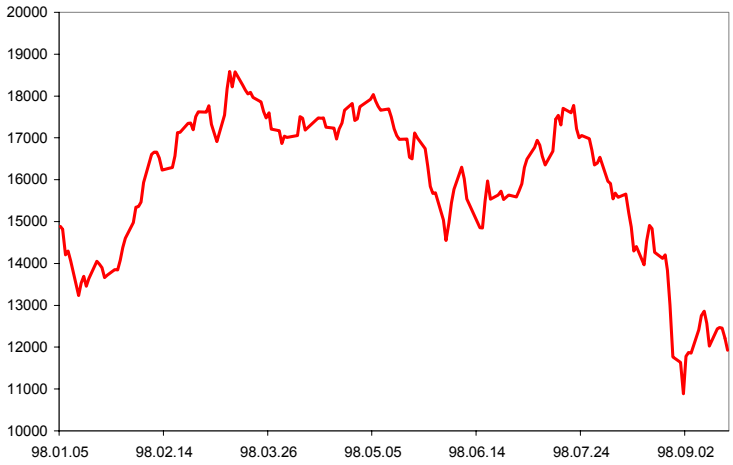

Figure 14: Warsaw Stock Index 1998

of the Ukrainian hrivnya on 4th September, and the abandonment of the band for the Slovakian koruna on 1st October.

However, central bank policy could have significantly contributed to the observed currency weakness. The NBH reduced interest rates significantly in late July and early August, and it was followed by a corresponding decrease in T-bill yields (see Figure 15). According to daily economic newspapers (e.g. Napi Gazdaság, 4. August 1998) markets interpreted this policy as *a*, a recognition of slowing inflation, and *b*, a tool to decrease the interest rate differential, thereby keeping exchange rates more volatile and preventing the country from excessive inflows of 'hot money'.

All in all, the Forint continued to depreciate, but has not reached the weak side of the band until early September. The NBH intervened several times intra-band to support the currency. During September practically the central bank was the only agent to buy Forint on the market. Figure 16 shows the volume of monthly NBH conversion for the relevant period. The futures exchange rates expiring 16th September were followed by decreasing forint liquidity in the interbank market, since banks closing their hedge for short Forint positions (against basket speculators) were buying basket currencies from the central bank. This lack of liquidity was one reason for increasing interbank interest rates. However, there was a parallel increase in T-bill yields, starting in mid-August for longer maturities and reaching its peak in a rapid run-up during the third week of September. Again, the central bank might have been responsible for part of this happening, since there were announcements on possible monetary tightening to defend the currency if necessary (see Figure 15). And indeed, in mid-September the NBH was forced to raise interest rates with 1 percentage point.

During October the pressure on forint eased, T-bill yields decreased, and the exchange

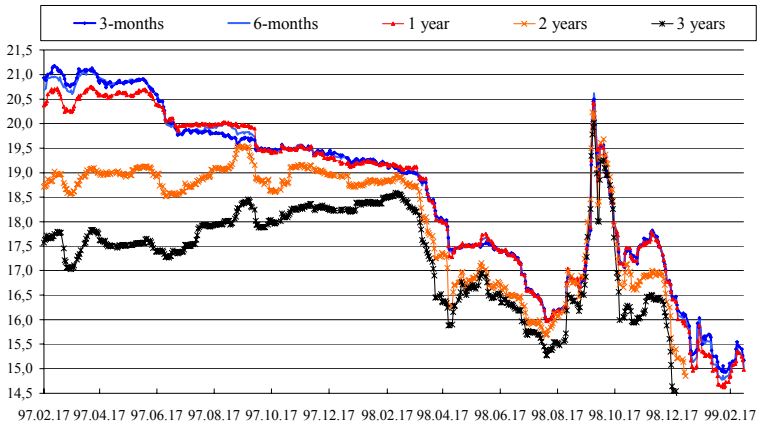

Figure 15: Hungarian T-bill yields for selected maturities 1997-98

rate left the weak side of the band, albeit did not immediately return to the strong side, and had been quite volatile for some time afterwards.

This is the story in short. From now on, we intend to understand on a deeper level what was actually happening, whether these events should be interpreted as a fall in the credibility of the Hungarian exchange rate regime, and if so, how serious.

At a quick glance, it seems that several components of a speculative attack were present. After all, the NBH had to defend the currency, treasury-bill yields significantly increased, and there was a parallel stock-market crash. It could have been a typical contagion crisis. However, a closer examination of the expectations of market participants will reveal a more subtle picture. Puzzle c, will turn out to be an efficient tool to deduce conclusions about these expectations, in a manner not entirely dissimilar to that seen in Section 5.1. It seems reasonable to start with some measure of credibility.

A classical method is the 'simple test' first proposed by Svensson in Svensson (1991) [15]. According to this method, one should plot for each trading day the futures exchange rate and the projected band expected to be valid upon maturity. Assuming full credibility a simple arbitrage argument convinces us that the former should lie within the area determined by the latter. Such graphs for the BCE basket futures prices have already been considered in the previous section from a different point of view (Figures 9-10). Taking yet another look at them indicates that according to Svensson's simple test the Hungarian regime failed to be perfectly credible for a period starting in mid-September, 1998.

Nevertheless, Svensson's test has its limitations. Firstly, failure in credibility according to this test means imperfect credibility in the sense that market actors attach positive probability to a possible realignment. The test per se does not measure quantitatively this

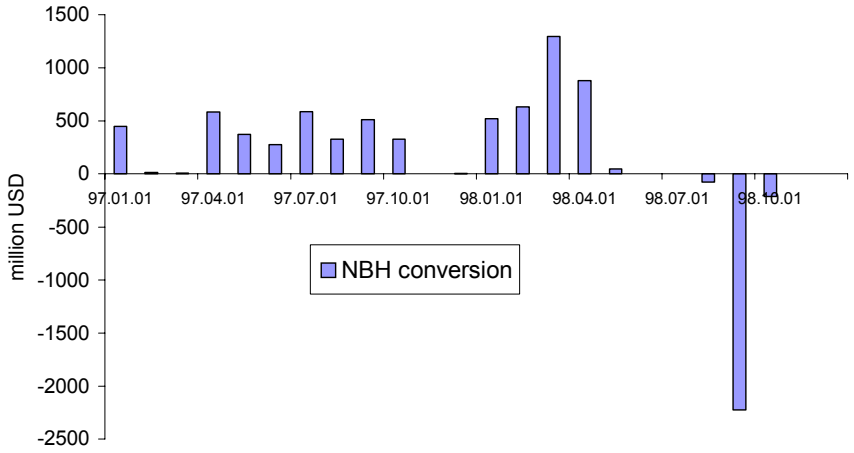

Figure 16: NBH conversion 1997-98

probability. Moreover, the no-arbitrage argument which forms the basis of the test may be questioned when market imperfections are present. Additionally, as it is pointed out in Garber-Svensson (1995) [9]: 'the assumption of perfect credibility is clearly rejected for most exchange rate target zones and most sample periods'. Using this comparison one may deduce that during the tranquil period the Hungarian regime was exceptionally credible, a conclusion which does not contradict our earlier analysis.

In order to get a more detailed picture of the credibility (or the lack thereof) of the regime during August-September it is necessary to understand at a more micro level what was going on in the market. It turns out that as late as August the basket speculation in favor of the Forint was continuing. According to NBH estimates (see [14]), long Forint positions of the size of tens of billions of Forint were opened during that month.[2] The speculators, using their recipe that has been consistently fruitful in earlier times, opened futures short positions in basket currencies expecting the exchange rate to return to the strong side. Banks comfortably took the corresponding long positions hedging their risks by selling foreign currency and investing in the Hungarian T-bill market (note that this is in fact the basis for CIP), probably arbitraging a small interest premium between implied and T-bill yields. The exchange rate did not return to the strong side, quite the contrary, and in the process of marking to the market basket speculators were forced to refill their margin accounts. Since there was high default risk on speculators, brokers acting on the futures market began to manipulate daily closing prices (which determine margin accounts). This is the reason for the observed large negative deviations from CIP in

[2]The estimates are obtained from comparing the change in the Forint value of Hungarian Treasury-bills owned by non-residents during August and exchange-rate sensitive currency outflow valid for that month. See the reference, pp.26-27 for details.

the period: Intra-day trading was, correctly, determined by covered interest rate parity, whereas the closing rates were considerably stronger in Forint terms than they should have been.

The rationale behind brokers' actions is explained by the structure of organized trading on the exchange. Consider the following example: A basket speculator wishes to open a long Forint position. She contacts her brokerage firm, and that in turn opens a contract with the exchange. Now imagine that the spot, and accordingly the futures Forint exchange rate substantially weakens. Then the client has to refill her margin account, otherwise the brokerage firm is forced to close the position. Imagine further that the client is unable to refill her account. She is then equally unable to pay the losses which result from closing the position at a weaker rate: in other words she defaults. Nevertheless, the brokerage firm has to stand for its contract with the exchange, and thus the debt burden of the client is transferred to the firm.

If closing rates are manipulated to be stronger than they should be according to CIP (say by some small contracts at the end of each day), in fact strong enough in order not to melt margin accounts, then default on the part of the basket speculator is not immediate. However, upon maturity the futures rate is determined by the spot rate, so manipulation can not go on forever. Suppose that there are two possible outcomes: *a*, The spot exchange rate strengthens back to the strong side of the band before maturity. Should this be so, the futures rate also strengthens, manipulation is no longer necessary, and the speculator is able to close the position without default. Thus the manipulation of the traders is justified in the sense that at a small cost (the contracts at the end of the day) they avoided losses which would have otherwise been inevitable. *b*,The spot exchange rate remains weak up to and including the date of maturity. In that case the client (in practice some of the clients) defaults, causing losses to the brokerage firm. However, without manipulation these losses would have equally hit the firm. So in any case manipulation causes no further harm, and it may have some advantages.

Since basket speculation was very typical of the BCE market, the above example has a chance of capturing part of the truth. Such behavior is sometimes referred to as an asset substitution effect. In our situation it may well be considered unethical, and the BCE set up a board to investigate the issue and prevent further manipulation in the future.

Supposing that all what has been said is correct, what conclusions can be drawn upon the expectations of market participants? On the part of basket speculators the answer is easy: at least during August, and probably even later on they expected the band to prevail and Forint to return to the strong side sooner or later. Indeed, there were rumors a few days before the expiration of the September 1998 futures about possible central bank intervention to strengthen the Forint for one day in order to help speculators avoid their losses.

The expectations of the brokers manipulating futures rates is a more ambiguous issue. It seems reasonable that they were hoping for an appreciating Forint so that their clients would not default. Especially so, if they felt that price manipulation has some legal risks.

But even if they gave only a slight chance to appreciation as opposed to a large chance of the abandonment of the band (for example), given that legal risks were (unfortunately) small, their actions seem to have been perfectly rational.

Based on the markedly different behavior of the two futures markets in August-September, it may be a helpful assumption to divide market participants into two groups. The first group shall be called basket speculators, who have already been examined. The second group is that of international portfolio-investors. During and following the Russian crisis there was extreme investor distrust in the region on the part of international investors. Raising fears of yet another emerging market crisis forced them to try to realize their profits and flee. This phenomenon accounts for rapidly falling stock prices. Foreign presence in the Budapest Stock Exchange during that period was estimated to be around 60%. It should be noted, that with such extensive foreign participation international investors could not simultaneously exit, the domestic demand for their equity being insufficient. This fact might explain the extremely large price decreases in the Budapest Stock Exchange compared to other markets in the region.

In the T-bill market yields started to increase in mid-August. Figure 12, plotting the volume of Hungarian government securities owned by non-residents indicates extensive selling. Exit from the T-bill market was significantly more pronounced then that from the stock exchange. Indeed, unless portfolio investors expected a very unfavorable economic scenario to follow, or were forced by clients, there was no reason for selling their stocks at such immensely depressed prices. One may also wish to distinguish between those non-residents investing in the T-bill and in the stock market, the former being probably more risk-averse institutions such as pension funds, fleeing at the first sight of danger.

In short, there was investor distrust towards the whole of the region, including Hungary. Such a distrust is naturally associated with a fall in the credibility of the regime. From this point of view the observed positive deviations from CIP on the London NDF Forint market may be interpreted easily. Positive deviations mean higher-then-domestic implied interest rates. It is quite possible that during that crisis period the implied interest rates of the London market mirrored well the expectations of international investors, better then T-bill yields, which were to a large extent determined by domestic monetary policy. In that case higher implied rates naturally imply higher devaluation expectations.

Of course, part of the pressure on the currency came from the investor exit outlined before. If the corresponding demand and supply elasticities are less then infinite, then this pressure may seriously contribute to the weakening of the exchange rate. Such a weakening might properly be described as the effect of transactional, rather then speculative money demand. A good proxy as to the size of this effect on the exchange rate may be the percentage depreciation of the Polish Zloty during the period. We have already noted that the credibility of the Zloty band was probably questioned only to a lesser extent; nevertheless there was a depreciation of more then 10% against the basket, likely due to similar transactional money demand. All in all, it seems that international investors had some doubts about the sustainability of the crawling band. However it is quite possible

that they were more concerned about realizing possible profits and avoiding further losses, and did not speculate directly against the Forint. So even if the credibility of the band was questioned, there was no speculative attack or the like.

A very good reason supporting this latter statement is the fact that the regime still prevails. It is not unrealistic to assume that international capital could have forced a successful speculative attack against the Forint, or for that matter any other similar regime in a small open economy. However there are costs of such an attack, and these may raise the question whether the success is worth the price. The existing capital controls in the country impose one such cost, by producing some difficulties as to the technical accomplishment of the attack. Moreover the relatively high ratio of reserves and the sound financial system compared to other countries in the region (see Árvai-Vincze (1999) [2]) also indicate that Hungary was less vulnerable to a crisis then some of its neighbors. As to the fundamentals one may draw a similar conclusion based on the above reference, which actually very thoroughly investigates the issue we are now at. Without further justification we wish to express here our view that the crisis Slovakia suffered was a fundamentally justified one, and the fact that Hungary and Poland were harmed only to a lesser extent by the contagion effect is similarly a consequence of healthier fundamentals and financial system.

Summing up, we feel that puzzles b, and c, have been more-or-less explained by expectations and market imperfections. It may also be deduced that Hungary experienced a fall in the credibility of the exchange rate regime during the aftermath of the Russian crisis, however the situation was not as dangerous as it might seem. It was not a speculative crisis; transactional money demand and again market imperfections account for much of the observed behavior.

5. Conclusions

In the present paper we analyzed the credibility of the Hungarian crawling band exchange rate regime for the time period April 1997-October 1998. Our basic tool was a careful study of market imperfections. The comparison with the similar regime in Poland often proved to be fruitful. We briefly list here our main conclusions.

1. In a world where markets are less than perfect, information involves costs, capital controls and transactions costs prevail, it can be misleading to directly deduce conclusions concerning the expectations of market participants due to the noise these factors introduce. In particular, for the case of Hungary and Poland, the behavior of the interest rate differential is guided more by monetary policy and less by expectations.

2. However, the analysis of market imperfections may serve as an additional source of information. More precisely, measures of no-arbitrage conditions and their evolution in time, as well as cross-country comparisons provide a different approach and help overcome some of the difficulties.

3. The observed one-sided deviations from CIP for the Forint during January-early May 1998 can be explained by basket-speculation in favor of the currency, and band-widening expectations (allowing more room for appreciation). Svensson's simple test also shows the regime to be highly credible.

4. During the aftermath of the Russian crisis there was a fall in the credibility of the Hungarian regime, but not, or only to a much lesser extent in that of Poland. Svensson's test and the deviations from CIP on the London NDF market prove this.

5..Nevertheless there was no speculative crisis in Hungary. To see the different expectations of different groups more clearly it is worth partitioning market actors into basket speculators and international investors. During August there was still (basket-) speculation in favor of the Forint. The weakness of the currency as well as the rise in interest rates during August-September are largely explained by transactional money demand on the part of international investors, not direct speculation.

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