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Czech Money Market: Emerging Links Among Interest Rates

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Comments Welcome

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Emerging Links Among Interest Rates

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Abstract:

The goal of this paper is to assess the money market in the Czech Republic from 1993 to 1997. The specific interest is in interactions between short and long interest rates, and between exchange and interest rates. During the financial crisis of 1997 the prevailing links among monetary variables tended to gain strength. The mutual links among interest rates provide clear proof that during the crisis the money market had became more efficient than at any time before. This was possible partially because of emerged arbitrage opportunities. The linkages show that turbulence and uncertainty enabled interest rates to again become the price of money as well as to influence the exchange rate. The exchange rate was found to influence only short-term interest rates.

Keywords: market efficiency, VAR, interest rates, exchange rates, causality

JEL Classification: E44, F31, G14

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Non-Technical Summary:

The present paper studies the inter-bank market in the Czech Republic from 1993 to 1997 (including the exchange rate crisis). The paper emphasizes interactions between short- and long-term interest rates, and between exchange and interest rates. During the financial crisis of 1997, the prevailing links among monetary variables tended to gain strength. The mutual links among interest rates provide clear proof that during the crisis the money market had became more efficient than at any time before. The linkages show that turbulence and uncertainty enabled interest rates to again become the price of money as well as to influence the exchange rate.

1. Introduction

Our goal is to assess the money market that has emerged from the recent financial crisis in the Czech Republic and to study the efficiency of the newly established inter-bank market. The interactions between short and long interest rates, and specifically a lead-lag relationship, are of general interest. In particular, we will study linkages between interest rates, as well as exchange rates, and compare the results of pre-crisis periods with those in the year of turbulence, 1997. While strong bilateral links support the hypothesis of market integration, a unilateral link leads to market segmentation and arbitrage opportunities.

In the beginning, there was a set of monetary arrangements and the central bank oversaw its monetary policy. Former Czechoslovakia officially started its economic transformation in 1991. From this time on, the role of the exchange rate could no longer be discounted as in the former centrally planned economy. At least at the beginning of the transformation, a certain reduction in the relative volatility of the exchange rate was desirable in order to promote export, direct foreign investments and generally favorable economic development during the transition to a free market economy.[1] The shock of the transition needed to be buffered, and therefore, introducing a floating exchange rate system would have been premature. A floating exchange rate regime requires that no restrictions on financial capital movement be imposed. This necessitates a strong mature

[1] With the absence of fully functioning financial markets, the newly emerged private sector was extremely vulnerable to exchange rate fluctuations. According to policy makers at that time, the fixed exchange rate provided a less volatile environment.

economy with sufficient reserves of convertible currencies. During the early stages of economic reform, the country did not meet these conditions, and an eventual bank run could have caused vast damage.

The temporary anchor of a currency basket peg was introduced in 1991 with a new level of base rates. The base rates were set quite high in order to be long lasting. In the beginning of 1993 Czechoslovakia was split into two independent nations. Monetary separation of the Czech and Slovak republics followed shortly after the formal division of the state.[2] From this point on the Czech crown has remained more or less stable, unlike its Slovak counterpart, which has devalued to a certain extent over time. Full convertibility of the crown was implemented on October 1, 1995, and meant that the crown was considered to be a convertible currency for current account and capital account transactions from this date on. However, this step was not paired with any change in the exchange rate regime, and thus the crown remained pegged to the currency basket.

Over the next few years several important changes took place. First, the CNB changed the composition of the basket on January 2, 1992, and then on May 2, 1993. From the latter date on, the basket was composed of the US dollar and the Deutsche mark at a ratio of 35:65. Second, there was a change of the fluctuation band. The band imposed on the basket was originally set at ± 0.5%. It was widened on February 28, 1996, to allow the index to fluctuate by ± 7.5%, while the exchange rate was still kept within the fixed regime.[3]

From the very beginning of 1997 the exchange rate started to appreciate significantly. In the middle of February it reached a local maximum of 5.5% above a central parity, and from then on it steadily depreciated. At first the fall was not very sharp and the rate even became steady in the beginning of May. A strong speculative pressure had emerged by the middle of May. CNB fought the speculative attacks for roughly two weeks with the help of foreign exchange interventions and with a sharp increase in interest rates. Then on May 26, 1997, the CNB abandoned the fixed exchange rate regime

[2] A detailed conditional variance analysis of the crown's evolution covering periods before and after the monetary separation can be found in Ko enda (1996).

[3] It is interesting to note that after the fluctuation band of the basket index was widened, the volatility of the exchange rate decreased. This non-apparent result is provided in Ko enda (1998).

and let the crown float freely with some unspecified tie to the Deutsche mark. The crown immediately devalued by 12-13%. This dive stopped quite quickly, and subsequently the crown strengthened and moved into the lower range of the original parity.

The devaluation of the crown acted as a natural pro-export feature and hurt the economy only mildly. The sharp increase in interest rates was the damaging factor, instead. The CNB ceased performing repo operations on May 15, 1997, and set a floating repo rate, which was dependent on the current market situation. The rates rose slightly. On May 16, 1997, the CNB increased the lombard rate from 14 to 50%, and during the next week it started to lower market liquidity with a 45 and later 75% repo rate. As a result of such strict monetary policy, short-term interest rates on the inter-bank market reached an unbelievable 200% and even peaked above 400%. Commercial banks were cut off from liquidity and acted accordingly. Tied to the subsequent appreciation of the currency, interest rates decreased but did not reach original levels.

To summarize, in the beginning of the financial crisis the crown immediately depreciated and subsequently started to appreciate. The interest rates skyrocketed to unparalleled levels and then started to decrease. If we try to normalize the evolution of the exchange and interest rates, then the situation after the crisis looks very much as it did before. Only the imaginary normalized gap is wider.

The relatively stable environment of the fixed exchange rate regime and semi-regulated interest rates provided a soft environment for the evolution of links among key interest rates. The bonds among interest rates tended to evolve in a weak economic sense. They naturally changed from 1993, when a modern banking sector emerged in the country. In 1996 these links were found to be quite independent. The peaceful evolution lasted till the beginning of 1997. Then turbulence started to sweep the entire industry and to erode the original arrangements.

It is not our purpose to discuss whether the interest rates were correctly or incorrectly set during the crisis. Rather we would like to take the interest rate settings as exogenous shocks and analyze what their impact was. During the turbulent times of a financial crisis, the prevailing links among monetary variables tend either to break or to

gain strength. The exogenous shocks of unprecedented interest rates might have either effect. Similar links are expected to exist between the exchange rate and interest rates.

The rest of the paper is organized as follows. The next two sections present the technology that tested the described questions and the data used. Section 4 provides our empirical findings and the last section briefly concludes.

2. Lead-lag Relationship via a VAR: Granger-causality Test

A usual vector autoregressive process (VAR) specification is

$$Y_t = A_0 + A_1 \cdot Y_{t-1} + \ldots + A_m Y_{t-m} + \mathrm{E}_t, \qquad (1)$$

where Y is a list of macroeconomic variables. A VAR is a non-structural model which simply estimates how variables are related to their lagged values over time. VAR models have been used extensively, in particular in macroeconomic forecasting. Several authors give a strong critique of structural models, arguing that VAR works better for forecasting and for policy evaluation (see Litterman (1979) and Sims (1980) among others).[4]

Since Granger (1969) introduced his definition of "causality," (see also Sims (1980)) the test of Granger-type causality has been applied quite frequently in a variety of empirical papers, including studies on market links. The methodology for testing linkages between markets is quite standard; see Agmon(1972), Easley et al. (1996), Hiemstra and Jones (1994), Hsiao (1981), Joy et al.(1976), Kwan et al. (1995), Smith et al. (1993), among others. A similar approach has been used to test interrelations between the cash market and stock index futures; see Chan (1992), Kawaller et al. (1987) and Shyy et. al. (1996), among others.

The described model fits our goal of studying the efficiency of the newly established inter-bank market in the Czech Republic. The interactions between short and long interest rates, and specifically a lead-lag relationship, are our general interest. In particular, we intend to study linkages between interest rates, and later between exchange rates and interest rates.

[4] On the other hand, VAR specification represents a reduced form of a structural model.

If the inter-bank market is efficient, then arbitrage and base trading will maintain the correct pricing relationship. This lead-lag relationship can be attributed to several specific factors: the unsettled character of the new market, the low volume of trade for some maturities, and institutional design. While strong bilateral links support the hypothesis of market integration, a unilateral link leads to market segmentation and arbitrage opportunities.

To test such a hypothesis we use the tool of Granger causality. We say that "$\{x_t\}$ causes $\{y_t\}$," when the lagged values of x_t have an explanatory power in regression of y_t on lagged values of y_t and x_t. The Granger causality is then tested via an autoregressive representation:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{bmatrix} a(L) & b(L) \\ c(L) & d(L) \end{bmatrix} \begin{pmatrix} x_t \\ y_t \end{pmatrix} + \begin{pmatrix} \varepsilon_t \\ \delta_t \end{pmatrix}. \qquad (2)$$

For a review of alternative tests see Geweke et al. (1983).

Because disturbances are serially uncorrelated, the direction of causality between $\{x_t\}$ and $\{y_t\}$ can be turned into a standard test of whether $b(L)=0$ and/or $c(L)=0$. The test of the hypothesis "$\{x_t\}$ causes $\{y_t\}$" is equivalent to the test of the restriction $b(L)=0$. Similarly, the opposite direction of causality can be tested via the restriction $c(L)=0$. The testing can proceed only if some restrictions on the autoregressive form (2) are specified before the actual estimation is done. For instance, we should identify the length of autoregression prior to estimation of (2). We applied Hsiao's (1981) two-step approach to determine the length of the lag structure. The linkages between inter-bank interest rates were examined in the context of the following models:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{k1} \alpha_i \Delta X_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta Y_{t-i} + \varepsilon_t \qquad (3)$$

$$\Delta Y_t = \chi_0 + \sum_{i=1}^{k3} \chi_i \Delta Y_{t-i} + \sum_{i=1}^{k4} \delta_i \Delta X_{t-i} + \nu_t, \qquad (4)$$

where

X_t and Y_t denote interest rates associated with different maturity.

For each maturity the proper pair of lag lengths (*k1*, *k2*) and (*k3*, *k4*) were specified using a search method over a range of lag lengths from 1 to 10. The choice of

the optimal lengths was based on standard information criteria — Akaike (1969), Hannan-Quinn (1979), Schwarz (1978). Thorton and Batetten (1985) show the sensitivity of the causal relationships (links) to the chosen number of lags. In particular, it is necessary to test whether both series are cointegrated.[5] Therefore, we did several robust checks, using the number of lags recommended by different information criteria. Moreover, we used six and seven lags of both the dependent and independent variables to test for market linkages. In all cases, we obtained the same results. Because the error terms were not autocorrelated and cointegration was not rejected for any equation, we tested the lead-lag relationship between the interest rates:

$H_0 : \beta_i = 0$ for all i, which means that there is no link from maturity Y to X

and

$H_0 : \delta_i = 0$ for all i, which means that there is no link from maturity X to Y.

3. Data

All the data we used were provided by the CNB. We used daily exchange rates of the crown in terms of the US dollar and the Deutsche mark. Further we used daily interest rates for different maturities. One is the **P**rague **I**nterbank **O**ffer Rate (PRIBOR); the other is the **P**rague **I**nterbank **Bid** Rate (PRIBID). Both rates were used in price quotations for: one day, one week, two weeks, one month, two months, three months, six months, nine months, and one year. We are aware of the fact that a one day rate is known to behave rather strangely sometime. However, we included this rate to cover the entire range of interest rates on the interbank market.

There was a total of 1131 observations, which were divided according to years in the following manner: 1993 with 229 observations, 1994 with 247 observations, 1995 with 245 observations, 1996 with 245 observations, and 1997 with 165 observations. The

[5] This is extensively illustrated by the standard methodology developed by Engle and Granger (1987).

years from 1993 to 1996 cover 12 months each. The data for 1997 covers a period of nine months.

As one might expect, the data are the first order integrated process. The analysis is therefore performed on the changes in exchange and interest rates between two consecutive business days.

4. Empirical Findings

The overall performance of the inter-bank rates from 1993 to the end of September 1997 is illustrated in Figure 1. For the sake of simplicity, the magnitudes of the inter-bank rates are presented only for the overnight rate. The picture shows a large peak during the financial crisis. A more important observation is that despite significant differences in the inflation rate during the period prior to the financial crisis, the interest rate was quite stable. In real terms, the rate was significantly negative and significantly below prime rates for the majority of Czech banks. The main point is that during the time of notably different inflation rates, the interest rate was kept more or less constant.

It is very useful to look at the spread, which is defined as the difference between offer and bid rate. The spread is often used as a proxy to measure the degree of stability on the market. Figure 2 shows the evolution of short-term interest rate spreads on the inter-bank market from January 3, 1993, to May 16, 1997, just immediately prior to the crisis. It can be concluded that the period before the crisis was characterized by a notable decline in spreads. This can be translated into low uncertainty in and low volatility of the money market.

In the beginning of 1993 the CNB stressed free reserve regulation in the banking system. Interest rates on the inter-bank deposit market rose until the middle of April. Relaxation of monetary policy starting in April led to a gradual decline in interest rates which continued until the end of the year. Tables 1 and 2 show that the leading rate for bids was one week, while the leading rate for offers ranged from one month to six months. This might imply that interest was primarily in long money. The one-day rate

had no meaning in this year, while the nine-month and one-year rates had not yet been introduced.

In 1994 developments on the money market were affected mainly by continuing foreign capital inflows and the CNB employed free market operations. Beginning in the second half of the year, interest rates increased. Tables 3 and 4 show that leading rates for both bids and offers were one-week rates. Similarly, in the case of both rates, the nine-month rate showed a tendency to affect market links as well. As for offers, the two-week rate had some impact too. As before, the one-day rate had no impact.

In 1995 foreign capital inflow affected the decline in money market interest rates. The CNB used a range of operations to sterilize the impact of this inflow on money market interest rates. Interest rates on total credits and deposits changed little throughout the year. Real interest rates on new credits and time deposits increased. An analysis of this year provides a disquieting view, which is illustrated by Tables 5 and 6. The market links weakened instead of strengthening. Weekly rates were no longer linked and one-day rates began to tie themselves to one and two-week rates. Other linkages show that short-term weekly rates were becoming leading rates. This might reflect an already emerging uncertainty in the economy. Long money definitely started to lose its position.

In 1996 foreign capital inflow had a smaller effect on money market interest rates. Turnover on the inter-bank deposit market grew substantially. The issue of the year, tighter monetary policy, resulted in an increase in interest rates. Tables 7 and 8 reveal surprising outcome. The interest rates lack any substantial link and, in plain fact, are not linked among themselves at all. This fact cannot be changed by a slightly better result in the case of offer rates. The outcome might very well have been caused by the small bank crisis that erupted in 1995. The deviant structure on the money market had possibly led to the bizarre situation in which the question of to whom a bank would lend was more important than the question of what the price of the loan should be. This is exactly when interest rates failed to give information essential to correct functioning of the money market. They stopped being the price of money.

So far, 1997 has been the most dramatic year on the money market since the beginning of the transformation. The crown has become the most traded currency of all transition

states. Interest rates were relatively stable at the beginning of the year. A financial crisis prompted their rise and stirred the foreign exchange market considerably. The fixed exchange rate regime was abandoned, but mild foreign exchange interventions remained on the agenda almost daily. Interest rates declined only slowly because of the reluctance of the CNB. The unprecedented uncertainty that started to peak during the financial crisis in the middle of the year is implicitly portrayed in Tables 9 and 10. The mutual links among interest rates provide clear proof that the money market was more efficient than at any time before. This was possible partially because of emerged arbitrage opportunities. The linkages showed that turbulence and uncertainty enabled interest rates to again become the price of money.

Again we examine the interest rate spread. Figure 3 presents the evolution of short-term interest rate spreads on the inter-bank market from May 17, 1997, to June 30, 1997. Naturally the magnitudes are very different than those before the crisis. The uncertainty in the market increased dramatically. The period after the crisis, from July 1, 1997, to September 30, 1997, is illustrated in Figure 4. This period showed a decrease in the interest rate spreads. However, the sudden gaps in spreads suggest that the market was still very sensitive to external shocks and the stability of the market was not comparable to the stability before the crisis.

We also researched links between the exchange rate and interest rate. Table 11 presents a comprehensive picture of the situation on the market in 1997. For both currencies (US dollar and Deutsche mark) there exists a strong link between short and long-term interest rates that have an influence on exchange rate. However, the opposite link - the exchange rate influencing the interest rate - was detected only for short-term interest rates.

The outcome of the financial crisis has become quite illustrious. The market is becoming more effective than before. Interest rates are beginning to represent the price of money. Mispricing is being weeded out thanks to newly emerged arbitrage opportunities and to deals on the money market itself.

5. Conclusions

The goal of this paper was to assess the interactions between short and long interest rates and between exchange and interest rates. In particular, we have studied linkages between interest rates, as well as exchange rates and interest rates, and compared the results of pre-crisis periods with those in a year of turbulence. While strong bilateral links support the hypothesis of market integration, a unilateral link leads to market segmentation and arbitrage opportunities.

The relatively stable environment of the fixed exchange rate regime and semi-regulated interest rates provided a soft environment for the evolution of links among key interest rates. The bonds among interest rates tended to evolve in a weak economic sense. They naturally changed from 1993, when a modern banking sector emerged in the country. In 1996 these links were found to be quite independent. The peaceful evolution lasted till the beginning of 1997, when turbulence started to sweep the entire industry and to erode the original arrangements.

It was not our purpose to discuss whether the interest rates were correctly or incorrectly set during the crisis. Rather we took the interest rate settings as exogenous shocks and analyzed what their impact has been.

During the turbulent times of a financial crisis, the prevailing links among monetary variables tended to gain strength. The mutual links among interest rates provide clear proof that the money market became more efficient during the financial crisis than at any time before. This was possible partially because of emerged arbitrage opportunities. The linkages show that turbulence and uncertainty enabled interest rates to again become the price of money as well as to influence the exchange rate. The exchange rate was found to influence only the short-term interest rates.

Table 1
1993: Bid

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D									
1W	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		
2W	$\rightarrow^{A}$	$\rightarrow^{B}$			$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{B}$		
1M	$\rightarrow^{A}$	$\rightarrow^{B}$				$\rightarrow^{B}$	$\rightarrow^{B}$		
2M	$\rightarrow^{A}$		$\rightarrow^{B}$			$\rightarrow^{A}$	$\rightarrow^{A}$		
3M	$\rightarrow^{B}$								
6M	$\rightarrow^{A}$								

$\rightarrow^{B}$ means the direction of a causality link at 5% significance level

Table 2
1993: Offer

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D									
1W	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{B}$			
2W	$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{B}$	$\rightarrow^{B}$			
1M	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{B}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		
2M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$		
3M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$		
6M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$			

Table 3
1994: Bid

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D							$\rightarrow^{B}$		
1W	$\rightarrow^{A}$		$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{A}$
2W	$\rightarrow^{A}$					$\rightarrow^{A}$			$\rightarrow^{A}$
1M	$\rightarrow^{A}$				$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{A}$
2M	$\rightarrow^{A}$					$\rightarrow^{A}$			$\rightarrow^{A}$
3M	$\rightarrow^{A}$								$\rightarrow^{A}$
6M	$\rightarrow^{A}$				$\rightarrow^{B}$	$\rightarrow^{A}$			$\rightarrow^{B}$
9M	$\rightarrow^{A}$				$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$
1Y					$\rightarrow^{A}$	$\rightarrow^{A}$			

Table 4
1994: Offer

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D									
1W	$\rightarrow^{A}$		$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{A}$
2W	$\rightarrow^{A}$			$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{A}$
1M	$\rightarrow^{A}$				$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{A}$
2M									
3M	$\rightarrow^{A}$				$\rightarrow^{A}$				$\rightarrow^{A}$
6M	$\rightarrow^{A}$				$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{A}$
9M	$\rightarrow^{A}$				$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{A}$
1Y									

Table 5
1995: Bid

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D		$\rightarrow^{A}$	$\rightarrow^{A}$				$\rightarrow^{B}$		
1W	$\rightarrow^{A}$			$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
2W	$\rightarrow^{A}$			$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
1M	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{B}$					$\rightarrow^{A}$	
2M	$\rightarrow^{A}$							$\rightarrow^{A}$	
3M	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{B}$					$\rightarrow^{A}$	
6M	$\rightarrow^{A}$							$\rightarrow^{A}$	
9M	$\rightarrow^{A}$								
1Y	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$					$\rightarrow^{A}$	

$\rightarrow^{A}$ means the direction of a causality link at 1% significance level

Table 6
1995: Offer

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D		$\rightarrow^{B}$	$\rightarrow^{B}$						
1W	$\rightarrow^{A}$			$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$
2W	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
1M	$\rightarrow^{A}$	$\rightarrow^{A}$						$\rightarrow^{B}$	$\rightarrow^{B}$
2M	$\rightarrow^{A}$	$\rightarrow^{A}$							
3M	$\rightarrow^{A}$	$\rightarrow^{A}$						$\rightarrow^{B}$	$\rightarrow^{B}$
6M	$\rightarrow^{A}$	$\rightarrow^{A}$							$\rightarrow^{B}$
9M	$\rightarrow^{A}$	$\rightarrow^{A}$							
1Y	$\rightarrow^{A}$	$\rightarrow^{A}$							

Table 7
1996: Bid

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D									
1W	$\rightarrow^{A}$								
2W	$\rightarrow^{A}$								
1M	$\rightarrow^{A}$								
2M	$\rightarrow^{A}$								
3M	$\rightarrow^{A}$								
6M	$\rightarrow^{A}$								
9M									
1Y	$\rightarrow^{A}$								

Table 8
1996: Offer

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D									
1W	$\rightarrow^{A}$	$\rightarrow^{A}$							
2W	$\rightarrow^{A}$								
1M	$\rightarrow^{A}$	$\rightarrow^{A}$							
2M	$\rightarrow^{A}$	$\rightarrow^{A}$							
3M	$\rightarrow^{A}$	$\rightarrow^{A}$							
6M	$\rightarrow^{A}$	$\rightarrow^{A}$							
9M	$\rightarrow^{A}$	$\rightarrow^{A}$							
1Y	$\rightarrow^{A}$	$\rightarrow^{A}$							

Table 9
1997: Bid

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D		$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
1W	$\rightarrow^{A}$			$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$
2W	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
1M	$\rightarrow^{A}$	$\rightarrow^{A}$			$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
2M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$		$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$
3M	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$
6M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	
9M				$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{B}$		$\rightarrow^{A}$
1Y	$\rightarrow^{A}$		$\rightarrow^{B}$	$\rightarrow^{A}$	$\rightarrow^{B}$		$\rightarrow^{A}$	$\rightarrow^{A}$	

Table 10
1997: Offer

	1D	1W	2W	1M	2M	3M	6M	9M	1Y
1D		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$		
1W	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		
2W	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$			
1M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{B}$	$\rightarrow^{B}$			
2M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{B}$		
3M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{B}$
6M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{B}$	$\rightarrow^{A}$			
9M	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		
1Y	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$	$\rightarrow^{A}$		

$\rightarrow^{A}$ means the direction of a causality link at 1% significance level
$\rightarrow^{B}$ means the direction of a causality link at 5% significance level

Table 11
Links among Exchange and Interest Rates: 1997

Rate	Causality, F-value	Currency		Causality, F-value	Rate
1 Day	7.64 →	USD	DEM	← 11.5	1 Day
1 Week	← 3.69 9.76 →			3.24 → ← 15.3	1 Week
2 Week	← 3.29 8.89 →			3.79 → ← 12.5	2 Week
1 Month	← 4.25 7.69 →			4.81 → ← 9.51	1 Month
2 Month	⇦ 2.14 8.97 →			2.09 ⇨ ← 13.8	2 Month
3 Month	9.54 →			← 13.9	3 Month
6 Month	12.3 →			← 21.3	6 Month
9 Month	11.2 →			← 20.7	9 Month
1 Year	10.9 →			← 19.6	1 Year

Arrow marks the direction of link/causality. → means significance at 1% level, and ⇨ means significance at 5% level.

Figure 1
One Day Offer Rate on the Prague Inter-bank Market:
January 3, 1993 to September 30, 1997

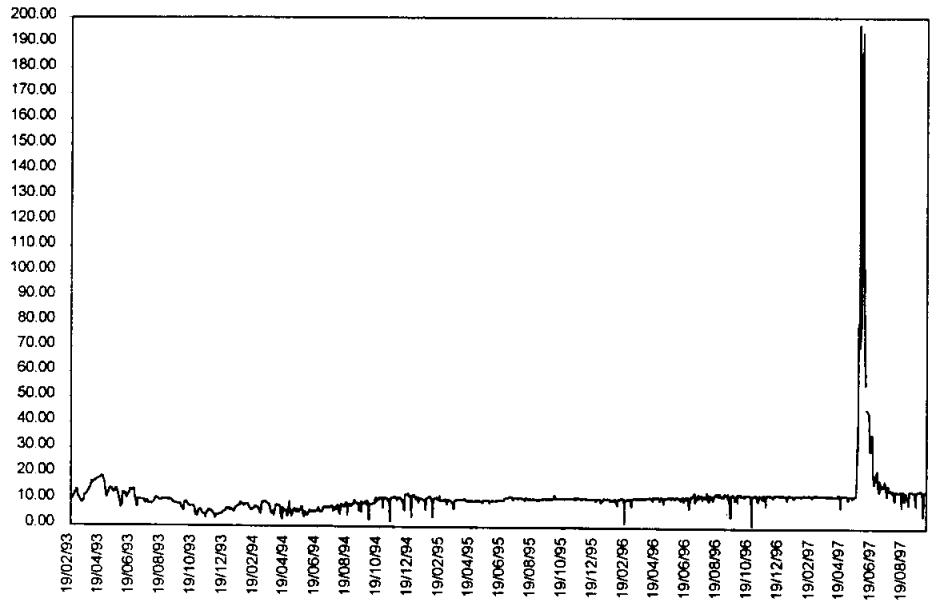


Figure 2
Short Term Interest Rate Spreads on the Prague Inter-bank Market:
January 3, 1993 to May 16, 1997

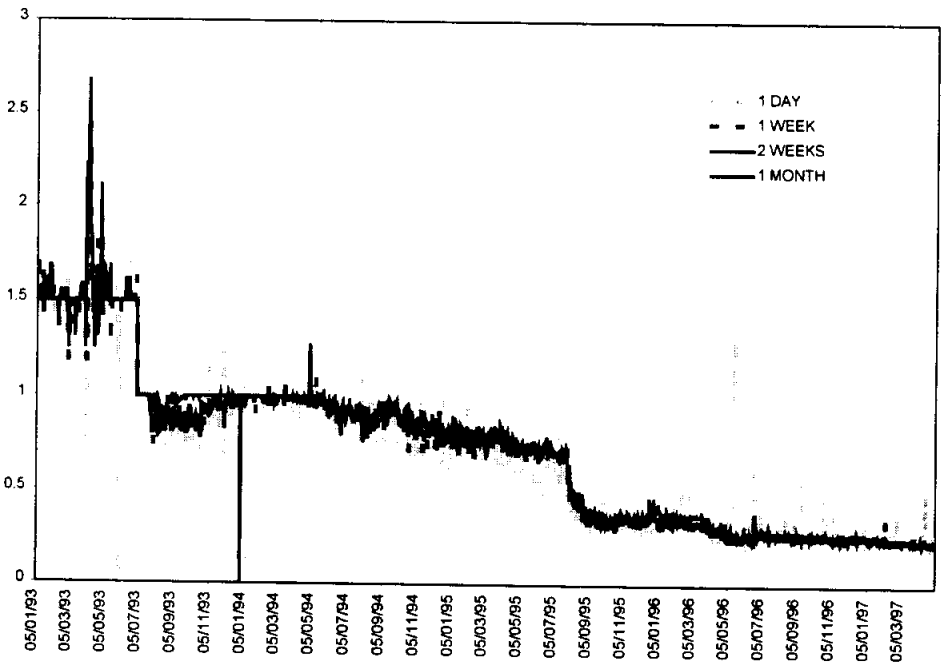


Figure 3
Short Term Interest Rate Spreads on the Prague Inter-bank Market:
May 17, 1997 to June 30, 1997

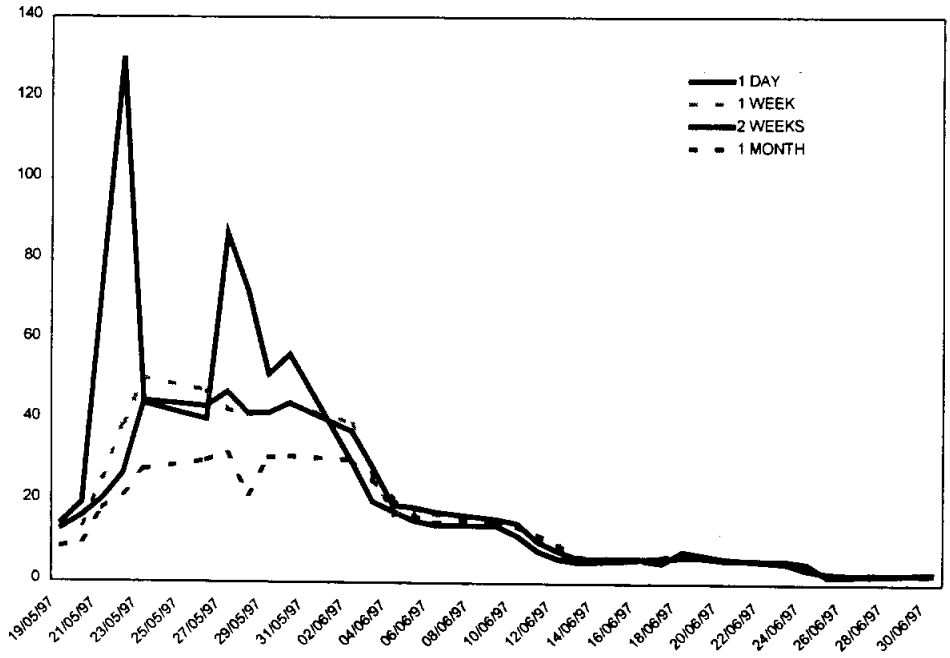
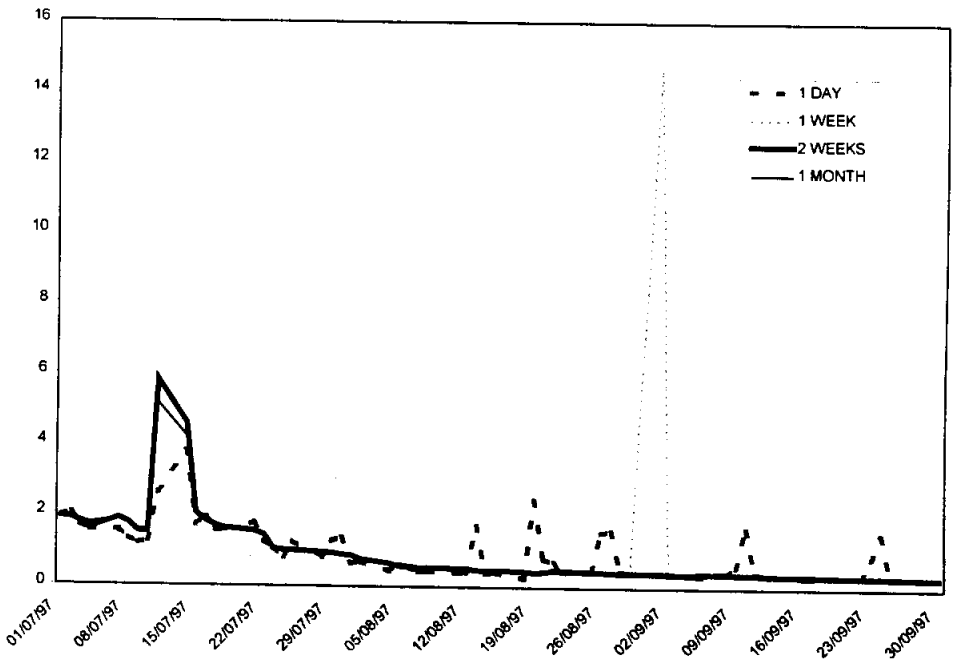


Figure 4
Short Term Interest Rate Spreads on the Prague Inter-bank Market:
July 1, 1997 to September 30, 1997



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