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What are the Differences Between the Currencies of Foreign Exchange Loans?

SUMMARY: Bank solvency is influenced by foreign currency lending – through fluctuations in the exchange rate of the currency on which the loans are based. The current paper analyses the extremity of these fluctuations and the time-variance of the currency correlations in the case of the Hungarian forint and Czech koruna (as a control variable) against the main FCL currencies like euro, Swiss franc and Japanese yen. We compared anomalies in the pricing of the currencies with the period before the crisis by dividing the five years of the crisis into three distinct periods on the basis of the main measures taken by the leading central banks, which impacted the currency markets. As a result of our analysis, we can conclude that following the development and prevalence of currency swap agreements, originally planned as a temporary measure, throughout the five year period, there was a reduction in the fluctuation of these floating currencies, combined with a decline in the historically close comovement of the European currencies. From an institutional development point of view, this serves to emphasise the significance of the crisis management model based on central banks' cooperation and assumes the supervisory and regulatory mandates of the monetary policy.[1]

KEYWORDS: divergence, Central and Eastern Europe, currency market, extreme movement
JEL-CODES: G15, G01, C32, E44, E58

The primary goal of monetary policy is to react to changes in the economic environment, as was the case during the period of pragmatic monetarism between 1979 and 1982, aimed at curbing the previous decade's inflation, or the prevailing price stability of the 1990's. Obviously, the latter may be accompanied by secondary goals (such as the growth and employment goals of Taylor's rule) or may even be reversed, as in the case of Japan's quantitative and qualitative easing, aimed at replacing deflation by price stability. Following the collapse of the Bretton Woods system and the emerging markets' crises of the nineties, the exchange rate as a goal has been struck off the global agenda and price stability appears as a valid demand also in member states contemplating to introduce the euro (as ESCB members). Financial stability, as a less than primary goal, continuously appears in legal regulations, while *Benati et al.* (2011) remark that although it is clearly necessary, it is difficult to put into practice. Today, there are two approaches regarding the operationalisation of this problem: one is the institutional approach – to transfer supervisory competencies to the central bank (MNB, 2013; Borio, 2014) or delegate them to community level (Szegedi, 2012) – and the other is to expand the tool-set, resulting in the extensive management of the yield curve – and not only in home currency.

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Over the course of the past five years, the transformation of central bank competencies was accompanied by the expansion of monetary instruments: compared to long-term or collateralised loan programmes used by the ECB, the asset purchase programmes of the Bank of Japan (BoJ) were much more aggressive, in addition to company securities (bonds, bills), they also include securities issued by property developers, and investment units traded on the stock market. Provision of foreign currency liquidity has also been constantly on the agenda since the end of 2007: leading central banks continue to do USD-currency swaps to this day, which indicates serious market allocation problems in the age of convertible currencies.

In Central and Eastern Europe, convertibility, floating currencies and price stability – as goals – meet with the demand for foreign liquidity (Kovács, 2009; Árvai et al., 2009), arising from the issue of underdeveloped money markets (Farkas, 2011). Among CEE countries, Hungary and Poland are characterised by the demand for foreign liquidity, caused by the loan-to-deposit ratios exceeding 100% (EBF, 2012), while a large proportion of loans was provided in foreign currency (Yesin, 2013) – the Czech currency, therefore, is a good basis for comparison, because the loan-to-deposit ratio was under 100% there and foreign currency loans were not as widespread. Considering that currency pricing uncertainties are related to a country's total debt, the Czech and Hungarian examples seem to be suitable for comparison on the liberalised capital market of Central and Eastern Europe. This comparison seems even more viable when we look at the statement by *Hudecz* (2012), according to which the similar household debts of the two countries (with different levels of sovereign and corporate borrowing) were coupled with completely different foreign currency exposure in 2008: while in Hungary it was close to 70 per cent, in the Czech Republic the ratio of FX loans was negligible.

This article aims to examine the currencies (Swiss franc – CHF, euro – EUR, Japanese yen – JPY) of Hungarian FX loans, using the methodology of applying the same tests for the Czech koruna (CZK) as the control currency. We conducted our tests by using the average overnight exchange rates between 1 January 2002 and 31 December 2013 (N=3035), using the database of the Central Bank of Poland[2]as the source. Our aim was to find out whether there had been changes in the relationship of HUF and other key currencies (meaning the distribution of extreme daily appreciation and weakening and the periods of comovement), compared to the pre-crisis period. We compared the various periods by dividing the total sample into four stages, differentiating the following periods: monetary tightening (between 1 May 2005 and 31 July 2007), subprime (between 1 August 2007 and 31 January 2010), interim (between 1 February 2010 and 30 November 2011) and responses to the euro crisis (between 1 December 2011 and 31 December 2013).

Exchange risk, arising during foreign currency lending, may have two reasons: changes in the currency of disbursement (in our case HUF) or the currency of funding (e.g. CHF, EUR, JPY). If masses of extreme fluctuations are only detected in one source currency, it may be advisable to manage that particular foreign currency exposure with a targeted approach (e.g. swap transactions between the ECB and the Bank of England on 17 December 2010 to manage the GBP liquidity of Irish banks[3]). On the other hand, if similar problems are detected in all source currencies, it is advisable to consider comprehensive consolidation measures (see e.g. Berlinger – Walter, 2013). In the case of a regional issue (the above-mentioned problems of several potential currencies of disbursement), decisionmakers should consider a community-level programme (such as the ECB–IMF–WB-programmes implemented at the end of autumn 2008 or the currency swaps after 2007). Apart from exchange risks, the difficulty of managing foreign currency lending stems from the fact that low interest rates mean low entry barriers at the time of allocation already, therefore, the structure of the asset portfolio is more heterogeneous, than in the case of HUF loans. Asset side problems cannot be managed with market solutions only.

MONETARY POLICY MEASURES

In this chapter, we first present arguments for connecting monetary policy and macro-prudential supervision, review the primary goals of central banks issuing key currencies, then examine which measures should be analysed from an exchange rate aspect. Finally, by reviewing certain central bank measures, we define the time windows which can be used to specify pre- and post-crisis periods.

In this section, we provide a brief overview of factors that render it more difficult to include financial stability among the monetary policy goals, however, according to Benati and *Goodhart* (2011,) necessitate the transfer of macro-prudential supervision to the central bank. Just to remind the reader: in Western Europe before the crisis, the separation of monetary policy and financial supervision was emphasised so that supervising the institutional system would not hinder central banks in achieving their main goals (Bánfi et al., 2011). The Timbergen principle can also be mentioned as the most basic counterargument against setting financial stability as a goal, which states that for each policy objective, a certain policy instrument should be assigned (e.g. using policy interest rates in the case of inflation targets). Bursting asset price bubbles did not seem avoidable even before the crisis; according to the Greenspan doctrine, it is cheaper to manage burst asset price bubbles subsequently with monetary policy measures, rather than go against the flow of market processes by using anti-cyclical policies. It should be emphasised, however, that in the European Harmonised Consumer Price Index (HCPI), both energy and property market price components are allocated a 10 per cent weight (ECB, 2011). Shocks on the asset side of banks have already been considered in monetary policies to a certain degree even before the crisis, although we have to agree with the paper by *Kolozsi* (2013), which stressed that the "one objective-one policy" approach had become outdated. The logic of Basel II regulations approaches the problem of managing the liability side of commercial banks in a way that "a solvent bank will always have access to liquidity on the market" (Benati – Goodhart, 2011). Lessons learnt from the crisis show that this automatism does not work: the BIS (2011) stresses the importance of central banks and international financial organisations in creating liquidity – which is a logical argument in favour of assigning supervisory competencies to central banks, due to the option of targeted measures. From an institutional aspect, it was pointed out by *Lawson* and *Zimková* (2009), as well as the National Bank of Hungary (2013), that as universal banking services were followed by the integration of financial supervision (Hungary: 1999, Poland: 2006), the lessons learnt from the "international life and national death" of the banking sector might require the combined supervision of liquidity and solvency, perhaps even complemented with the banking union, described by *Darvas* (2013), on a community level, however, based on *Pelle* (2006), it would be necessary to harmonise and integrate supervisory functions at least. Assuming that such a community-level solution is able to manage the access to liquidity of banking networks in the CEE region. Regarding our sample, we must note that in the Czech Republic, banking supervision has been assigned to the central bank since 1993, followed by granting capital market and insurance supervisory competencies later. [4]

In our view, this summary is necessary, because we intend to proceed by describing the unique evolution of the management of FX liquidity by central banks.

According to Paragraph (1) of Article 127 of the Treaty on the Functioning of the European Union, the primary objective of the European Central Bank shall be to maintain price stability. Without prejudice to the objective of price stability, the ECB can support the objectives of full employment and balanced growth. According to [5] Paragraph (1) of Article 5 of Federal Act no. 951.11 on the Swiss National Bank (3 October 2003), the primary objective of the SNB is to ensure price stability. Article 2 of[6] the Bank of Japan Act (Act No. 89 of June 18, 1997) also prescribes price stability as an objective, however, the BoJ's decision on quantitative and qualitative monetary easing (4 April 2013) also introduces the rather aggressive expansion of the monetary base (an annual 60-70 JPY expansion of the 138 billion JPY base at the end of 2012), with the aim to increase the price level to 2 per cent within two years.[7]

The independence of central banks in the territory of the EU means the national and community level institutional independence of monetary policies (Article 130 of the Treaty on the Functioning of the European Union), similarly to Switzerland (Article 6 of the aforementioned Federal Act and Article 99 of the Constitution of the Swiss Confederation). On the other hand, Article 4 of the Bank of Japan Act talks about maintaining close contact with the government, as well as the mutual compatibility of monetary, currency and economic policies. The autonomy of monetary policy, however, means that the central bank has room to manoeuvre in the capital market: we can talk about autonomous monetary policy if central bank measures are driven by the desire to reach the primary goal[8] (Bearce, 2002b). This may be curbed by the monetary policy of central banks that issue key currencies, the openness of the balance of payments (Plümper – Troeger, 2008) and the pro-cyclicality of the financial system, due to global liquidity flows (BIS, 2011). Small open economies may try to declare the independent floating of currencies (explicitly removing this from monetary policy goals), but this will affect medium-term price levels through the exchange rate channel of the transmission mechanism. Furthermore, due to the external funding of the economy (generally, the use of external funds in the case of an over 100 per cent loan-to-deposit ratio and specifically foreign currency lending) it will even dominate the channels of interests and expectations by influencing consumption and investment decisions.

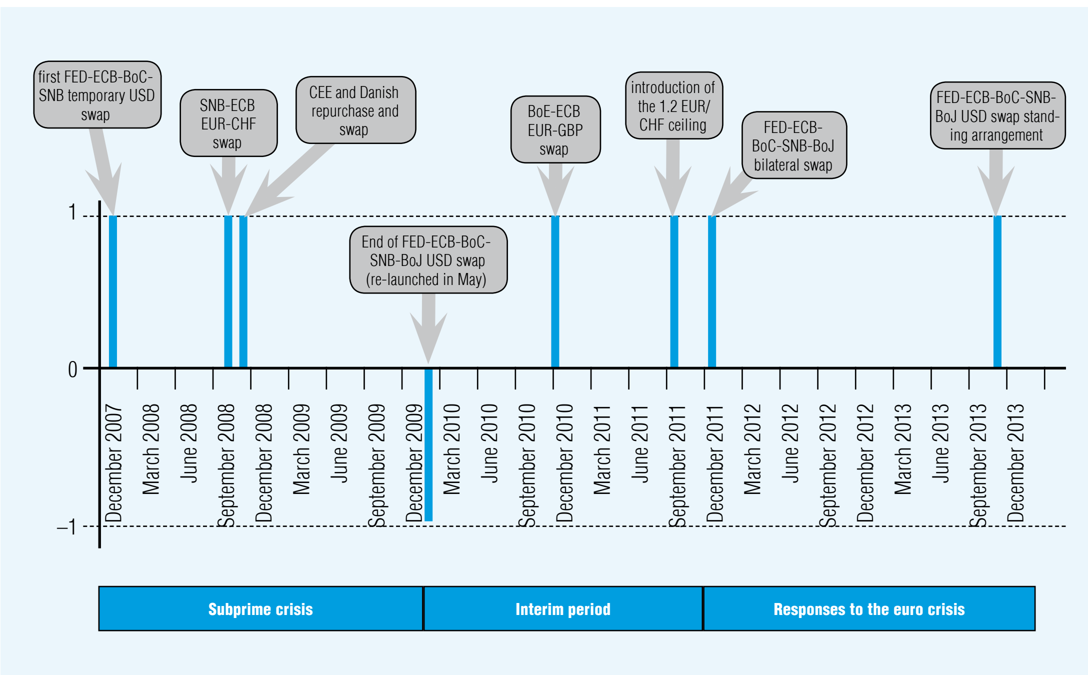
In this chapter, we apply the previously outlined arguments to discuss the decisions of central banks that issue the key currencies of foreign currency loans. Our work is rendered much more difficult by the fact that *Kiss* and *Kosztopulosz* (2013) used the progression of ECB policy interest rates to determine pre-crisis (between December 2005 and October 2008) and crisis (between October 2008 and July 2011) periods. During the crisis management period, leading central banks eventually reached the zero lower bound rate, therefore, they had to introduce further measures, as mentioned in our introduction. As the present paper focuses on the currency market, instead of discussing attempts to reinvigorate the securities market [which is examined by Győrfi (2013) in detail], we choose to analyse currency swaps. On 12 December 2007, the Bank of Canada, the Bank of England, the Swiss National Bank, the ECB and the FED have announced the first temporary USD swap agreement[9] (with the Bank of Japan joining later, on 18 September 2008[10]), which, apart from a break between February and May 2010, was continuously extended until 31 October 2013[11], from which date the existing temporary liquidity swap arrangements were converted to standing arrangements between these 6 leading central banks. This programme was complemented with a bilateral swap agreement, introduced on 30 November 2011,[12] allowing the above central banks to authorise swap arrangements to provide liquidity in any of their currencies. In addition to the above measures, on 15 October 2008, EUR/CHF foreign exchange swaps were launched between the Eurosystem and the Swiss National Bank, which are being extended to this day[13], and on 17 December 2010 a temporary GBP/EUR[14] liquidity swap facility was launched. In October and November 2008, the ECB announced swap and repurchase agreements with the central banks of Hungary[15], Denmark[16] and Poland[17]. An actual exchange rate policy measure was taken by the Swiss National Bank only, when on 6 September 2011 it decided to stop the further appreciation of the Swiss franc by introducing a minimum EUR/CHF exchange rate of CHF 1.20 (SNB, 2012). All central banks involved applied a floating exchange rate policy.[18]

Using the changes in the policy interest rate and the dates of the swap agreements, we compare the following periods *(see Chart 1):*

- monetary tightening (rising interest rates, period between 1 May 2005 and 31 July 2007, *N*=610),
- subprime (falling interest rates and the first round of the swap agreements, period between 1 August 2007 and 31 January 2010, *N*=633),

Chart 1

MAIN CENTRAL BANK SWAP TRANSACTIONS IN THE VARIOUS PHASES OF THE CRISIS



Source: own calculations

- interim (more swap agreements, sovereign crisis and the introduction of the CHF exchange rate ceiling, period between 1 February 2010 and 30 November 2011, *N*=467)
- and the responses to the euro crisis (introduction of the bilateral swap agreement, period between 1 December 2011 and 31 December 2013, *N*=522).

METHODOLOGY

In the course of our paper, we examine the extreme movement of Central and Eastern European currencies (Czech koruna and Hungarian forint) against the leading currencies (euro, Swiss franc and yen), its timing and changes in their comovement during the period defined in the previous chapter. For this, we first need to define extreme movements and the three methods of their measurement, as well as the methodology of calculating correlations, relying on our previous work (Kiss – Kosztopulosz, 2012) for the latter.

International finance often reaches for the definition of sudden cessation of liquidity flow if they experience an unexpected decrease in the inflow of foreign capital greater than two standard deviations (Frankel 2011). The present study groups the currencies' fluctuations (or "returns", which we determine as logarithmic differentials of the currency rate) into two complimentary sets: extreme and normal movements. In our paper, we refer to those sets of returns as r_n *normal return* (1) which have a higher than 5 per cent probability of fitting well to the normal distribution – using Fama's (1970) expected normal distribution hypothesis from pages 384 and 399 of his paper.[19]

$$p(r_n) \geq 5\% \text{ és } f(r_n) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(r_n-\mu)^2}{2\sigma^2}} \quad (1)$$

Assuming that the returns of the currency markets included in our sample can take r_n normal and r_x extreme values, we are talking about capital market shock which we denote with $r_{n/x}$. In the case of $r^{m_i}_{n/x}$=0 (2), we can not talk about the existence of shock because of the lack of extreme returns, while in the case of $r^{m_i}_{n/x}$≠0 (3) we can.

$$r^{m_i}_{n/x} = 0 \longrightarrow r^{m_i} = r^{m_i}_{n} \quad (2)$$

$$r^{m_i}_{n/x} \neq 0 \longrightarrow r^{m_i} = \begin{cases} r^{m_i}_{n} \\ r^{m_i}_{x} \end{cases} \quad (3)$$

For a deeper formulation of extreme movement, we use the definition of extreme events by *Jentsch et al.* (2006) whereby among the *W* stochastic variables (in our case currency movements) such $w_x \in W$ extreme events occur, which we can characterise as having $w_{x+} >> w_n$ or $w_{x-} << w_n$ a great effect, or $p(w_x) << p(w_n)$ low probability. This is, in large part, similar to the extreme value concept of *Jiawei* and *Micheline* (2004), in which they speak of data elements which drastically diverge from the other components of the data set. The determination of this requires an organising principle which identifies data set inconsistency. In the course of our statistical approach, we focus on the contradictions between the sample's theoretical and empirical distribution, while during distance-based procedures, we reveal the outlier elements with the help of cluster analysis. On the basis of all this, in the $r \in R$ exchange rate changes data set, we distinguish between the r_x extreme returns' set, in which the probability of $p(r_x) << p(r_n)$ is extremely low and the $r_{x+} >> r_n$ *or* $r_{x-} << r_n$ level of movement significant. In the detection of extreme returns we used three methods, built on a reduction of: in the first approach the movement's low (less than 5 per cent) probability, in the second its deviation from the normal distribution and in the last the fourth moment (peakedness, kurtosis) to 3 – the capital market returns' power distribution assumption (in its simplest form

$r=k^a$) by *Gabaix et al.* (2003) being important for us.

We call extreme returns with a probability of less than 5 per cent r_{vx} *improbable returns* (4). Their presence is allowed by the assumption of normal distribution but in much lower volume than is the case for fat-tailed distribution.

$$p(r_{vx})<5 \text{ per cent and } r_{vx-}<<r_n<<r_{vx+} \quad (4)$$

This solution, following the logic of the Value-at-Risk method, matches the time series with a theoretical normal distribution and places those movements with a probability of less than 5 per cent in the improbable returns' set. Consequently the method places, on both sides, the same number (3,035×0.05=151 or 152) of elements in the extreme set – being, in total, indifferent to any asymmetry in the extreme movements (for example a given currency experiencing many extreme devaluations in the past followed by fewer appreciations).

The existence of r_{fx} *fat-tailed returns* is a result of the empirical fat-tailed distribution of returns, while, as a function of the asymmetry of the probability distribution, they appear to differing degrees on both sides of the probability distribution, their number and probability, however, diverging to a large extent from the E (r) expected value. For this, we use their QQ plot "S" shaped distribution, after *Clauset* (2007), and in the spirit of Jiawei and Micheline (2004) make a statistical estimate based on the assumed normal truncated distribution.

$$r_{fx}+\gg E(r), \text{ or } E(r)\gg r_{fx}-; \text{ where } Pr_{fx}\ll p_{E(r)} \quad (5)$$

For the presentation of the logic of the Quantile-Quantile plot, we rely on pages 690-691 of *Deutsch*'s book (2002).

Using the QQ plot, we can select extreme returns as follows (6):

$X_i=\phi_1^{-1}(p_i)=\phi_1^{-1}(i/T)$ for each $i<T$, thus:

$$r_n\approx\mu_2+\sigma_2X_i,$$

$$r_{fx}^{+}>\mu_2+\sigma_2X_i,$$

$$r_{fx}^{-}<\mu_2+\sigma_2X_i, \quad (6)$$

where X_i matches the theoretical standard normal distribution, which is a sloped straight line.

The r_{ox} *outlier returns* (9) are members of a cluster with a small number of elements, and are responsible for all of the sample's high (above 3) kurtosis. We can arrive at the outlier returns through the systematic segmentation of the sample, whereby we cluster the total population until the largest cluster's fourth moment equals 3.

$$r_{ox}\in\mathbb{O} \text{ and } \mathbb{D}=\mathbb{O}\cap\mathbb{N} \text{ where } E_{\mathbb{D}}[(r-\mu)^4]\gg3$$
$$\text{and } E_{\mathbb{N}}[(r_n-\mu)^4]\approx3 \quad (7)$$

In formula (9), $\mathbb{D}$ denotes the total sample, $\mathbb{O}$ denotes the r_{ox} outlier returns' set, while $\mathbb{N}$ the normal returns' set. During the examination, we divided the sample, using hierarchical cluster analysis, into clusters from 1 to 200 and then searched for the clustering procedure which resulted in the least number of clusters, where the biggest cluster's kurtosis had a value of less than 3. Using the wide intervals for the number of clusters was justified by our experience that the formation of 73 and 134 clusters was necessary for the largest cluster's kurtosis to be below 3.

Using the so-called system-embedded nature of the extreme returns (that is, after Kantz et al. (2006) we assume that a system's tendency to excess depends on this structure), it is more favourable to examine the currency markets than the scale-free networks with a tendency to leave their state of equilibrium, as described by *Barabási* and *Albert* (1998).[20] We can distinguish between two kinds of collective behaviours: contagion and divergence, while in the absence of the above, we can speak of interdependence.

Capital market contagion[21] (8) means a significant increase in the correlation between markets m_k, m_j $p^{m_k m_j}$ as a result of a shock $r_{n/x}$ (Forbes – Rigobon, 2002; Campbell et al., 2002; Bekaert et al., 2005):

$$r^{m_i}_{n/x} \neq 0 \rightarrow p^{m_k m_j}_{n} < p^{m_k m_j}_{x}, \qquad (8)$$

accordingly, in so far as trading days in the m_i market can be divided into normal and extreme return sets on the basis of the defined $r_{n/x}$ shock, we then divide the $p^{m_k m_j}$ correlation between the m_k, m_j markets into two parts and observe a significantly higher correlation in the period characterised by the shock.

Capital market divergence (9) is defined as a significant decrease in the correlation between the markets $m_k m_j$ $p^{m_k m_j}$ as a result of external or internal shock $r_{n/x}$ (Bearce, 2002a):

$$r^{m_i}_{n/x} \neq 0 \rightarrow p^{m_k m_j}_{n} < p^{m_k m_j}_{x}, \qquad (9)$$

accordingly, in so far as trading days in the m_i market can be divided into normal and extreme return sets on the basis of the defined $r_{n/x}$ shock, we then divide the $p^{m_k m_j}$ correlation between the m_k, m_j markets into two parts and observe a significantly lower correlation in the period characterised by the shock.

We can speak of *Capital market interdependence* (10) in the case of no significant change in the correlation between $m_k m_j$ markets $p^{m_k m_j}$ following an external or internal shock $r_{n/x}$ (Forbes – Rigobon, 2002):

$$r^{m_i}_{n/x} \neq 0 \rightarrow p^{m_k m_j}_{n} \approx p^{m_k m_j}_{x} \qquad (10)$$

accordingly, in so far as trading days in the m_i market can be divided into normal and extreme return sets on the basis of the defined $r_{n/x}$ shock, we then divide the $p^{m_k m_j}$ correlation between the m_k, m_j markets into two parts and do not observe a significantly higher correlation in the period characterised by the shock. It is important to note that in the present paper, contrary to Kiss – Kosztopulosz (2012), we do not examine the changed conditional correlation on trading days characterised by extreme movements, but are interested in the changing correlations in the various phases of the crisis. Based on the article by *Capriello, Engle and Sheppard* (2006), for the calculation of conditional correlations, we first used univariate APARCH–GRJ GARCH–TARCH–GARCH models, with various lags, matched to examine the time series' heteroscedasticity, and then, after calculating Engle's (2002) Dynamic Conditional Correlation (DCC GARCH), we used the Ansari–Bradley- (A–B-) test[22] to examine the significance of deviations between individual time windows. This was necessary because of the A-B test's insensitivity to distribution.

RESULTS

The Central and Eastern European currencies examined (Czech koruna – CZK and Hungarian forint – HUF) showed differing degrees of fluctuation against various key currencies (Swiss franc – CHF, euro – EUR and Japanese yen – JPY) in the period between January 2002 and December 2013. The lowest degree of fluctuation in the currencies examined was seen against the euro while in the case of the Swiss franc and the Japanese yen, we observed more serious movements *(see Chart 2)*. During the period of monetary tightening ("SZ" denoted period between 1 May 2005 and 31 July 2007), both currencies strengthened compared to the subprime period ("S" denoted period between 1 August 2007 and 31 January 2010) which was characterised by a general weakening. After this, we only observed strengthening in the case of the Czech koruna against the euro in the interim period ("I" denoted period between 1 February 2010 and 30 November 2011). In the period marked by responses to the euro crisis ("E", from 1 December 2011 to 31 December 2013), the currencies continued to weaken except against the yen. We must note, however, that in the case of the Czech koruna, we observe much less dramatic movements and cannot speak of devaluation at the end of the time period compared to January 2002 – in contrast to the forint.

In the course of our analysis of exchange rate changes in the total period examined (*see Table 1*), we could observe the lack of normal distribution, volatility clustering (heteroscedasticity) while the Czech koruna showed an inclination to autocorrelation. The third moment's (skewness) negative value carries with it the mark of the weakening during the time of the crisis, a great mass of which is recorded by the Czech koruna and the forint. Interestingly, denomination in the Swiss franc is quite capable of neutralising this effect. The fourth moment (peakedness, kurtosis) is greater than 3in all cases, which means fat tails. It should be noted that low probability yet severe movements are present when measuring in Swiss francs – compared to this the Japanese yen is standard – despite what can be seen in *Chart 2*.

The calculation in Swiss francs before the crisis is associated with lower kurtosis than in the case of the euro *(see Table 2)*. The relationship between the koruna and the forint developed in a peculiar fashion – while prior to the crisis, the koruna's kurtosis was less than half of that of the forint, over the whole time series, in the case of the Swiss franc and the euro, we observed a greater kurtosis than for the forint. In the case of the koruna, therefore, we witness an increase in extreme movements as a result of the crisis – less characteristic in the case of the forint.

If we would like to examine the tendency to extreme movement in more detail, in *Table 3* of the three methods presented, the fat-tailed and clustered returns allow the deepest examination: following the reduction of the fourth moment to below 3, in both cases, the forint exhibited a greater number of extreme trading days. Comparing with Chart 2, this means

Table 1

THE EXAMINED CENTRAL AND EASTERN EUROPEAN CURRENCIES' LOGARITHMIC DIFFERENTIALS' BASIC STATISTICS AGAINST VARIOUS DENOMINATIONS

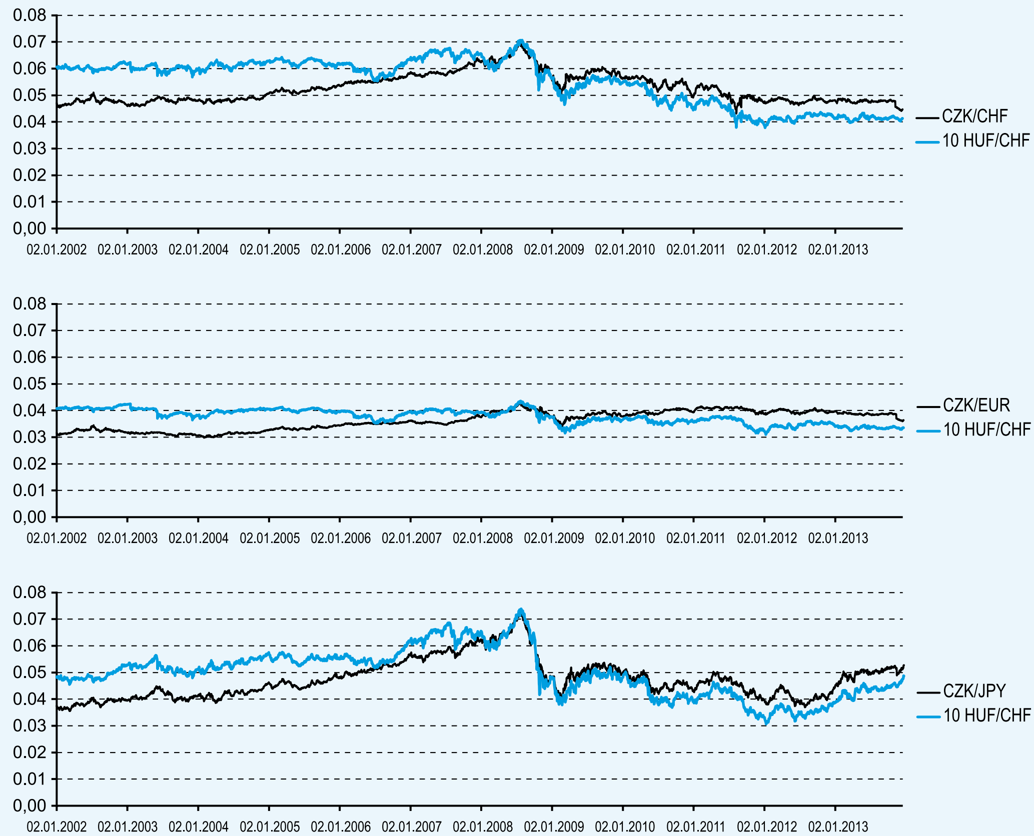
Denominator	Currency	Skewness	Kurtosis	Normal distribution	Autocorrelation	Heteroscedasticity	Stationary
				Jarque–Bera (p)	Ljung–Box (p)	ARCH–LM (p)	ADF (p)
CHF	CZK	0.7750	20.4057	0*	0.9222**	0.9777***	0****
	HUF	–0.0048	13.2339	0*	0.0109	0.2468***	0****
EUR	CZK	–0.3175	12.3465	0*	0.1259**	0.4409***	0****
	HUF	–0.6258	11.0656	0*	0.0152	0.3109***	0****
JPY	CZK	–0.3609	7.4581	0*	0.7879**	0.9143***	0****
	HUF	–0.5120	9.1864	0*	0.0549**	0.4361***	0****

*Note: *: absence of normal distribution, **: autocorrelated with 2nd lag, ***: heteroscedasticity with 2nd lag, ****: stationary*

Source: own calculations

Chart 2

CURRENCY EXCHANGE RATE DEVELOPMENTS IN THE PERIOD EXAMINED



Source: own calculations

that, in contrast with the symmetrical nature of the Czech koruna's extreme movements, in case of the forint, days of extreme weakening are dominant. This picture is reinforced by the wider intervals set for the forint (that is to say that this currency has to undergo much greater movements to be considered extreme whichever method is used). The success of the definition of extreme movement is indicated by the fact that the returns thus defined characteristically make up 10 per cent of the total sample (5 per cent on each side) which is really a sign of unusualness. An exception to this is the forint measured against the Swiss franc and the euro where, to arrive at a kurtosis of 3 required substantial clearing of the sample.

The time distribution of the currencies' extreme movements closely follows that of the various periods of the crisis *(see Table 4)*. Within this, extreme fluctuations are expressly more frequent in the subprime ("S") period, where 5–6 per cent of trading days showed extreme jumps in the case of probability and cluster-based methods. A calmer market mood is demonstrated by the drop in the extreme exchange rate fluctuation against the euro and the Japanese yen in the interim ("I") period (although it was much more subdued in the

Table 2

THE EXAMINED CENTRAL AND EASTERN EUROPEAN CURRENCIES' FOURTH MOMENT IN VARIOUS PERIODS AND AGAINST VARIOUS DENOMINATIONS

Period	Denominator	Currency	
		CZK	HUF
Total time series	CHF	20	13
	EUR	12	11
	JPY	7	9
2002–2008	CHF	5	10
	EUR	6	16
	JPY	4	8

Source: own calculations

Table 3

THE EXAMINED CENTRAL AND EASTERN EUROPEAN CURRENCIES SHOWED EXTREME MOVEMENTS WITH THE DIFFERING METHODS

Denominator		CHF		EUR		JPY	
Currency		CZK	HUF	CZK	HUF	CZK	HUF
Total	kurtosis	20.4057	13.2339	12.3465	11.0656	7.4581	9.1864
Improbable return (r_{vx})	kurtosis rn	2.5506	2.8554	2.5665	2.8114	2.5894	2.6949
	r(x+) min	0.8846	1.2171	0.6583	0.9470	1.4348	1.6949
	r(x-) max	–0.9020	–1.3451	–0.6201	–1.0689	–1.5128	–1.9268
	no. r(x+)	151	151	151	151	151	151
	no. r(x-)	152	152	152	152	152	152
	%r_x	10%	10%	10%	10%	10%	10%
	no. r_n	2733	2733	2733	2733	2733	2733
Fat-tailed return (r_{fx})	kurtosis rn	3.1535	3.2369	2.9722	3.1395	2.8500	3.0443
	r(x+) min	1.3124	1.8133	0.8154	1.4417	1.9734	2.6963
	r(x-) max	–1.2306	–1.5196	–0.8284	–1.1391	–1.6359	–2.0328
	no. r(x+)	53	54	84	44	69	44
	no. r(x-)	78	124	76	129	137	138
	% r_x	4%	6%	5%	6%	7%	6%
	no. r_n	2903	2856	2874	2861	2828	2852
Clustered return (r_{cx})	kurtosis rn	2.9894	2.9869	2.8407	2.9327	2.9584	2.9309
	r(x+) min	1.0710	1.0143	0.6047	0.7982	1.6943	1.9083
	r(x-) max	–0.9895	–0.8809	–0.6607	–0.6619	–1.6480	–1.7050
	no. r(x+)	92	213	176	208	96	107
	no. r(x-)	125	310	133	341	133	192
	% r_x	7%	17%	10%	18%	8%	10%
	no. r_n	2816	2510	2723	2484	2804	2734
	no. clusters	74	134	73	107	50	89

Source: own calculations

Table 4

TIME DISTRIBUTION OF THE EXAMINED CENTRAL AND EASTERN EUROPEAN CURRENCIES' EXTREME MOVEMENTS

	Denominator	CHF				EUR				JPY			
Method	period	CZK		HUF		CZK		HUF		CZK		HUF	
r_{vx}	SZ	8	0%	23	1%	23	1%	36	1%	7	0%	13	0%
	S	120	4%	119	4%	140	5%	131	4%	138	5%	148	5%
	I	107	4%	114	4%	35	1%	53	2%	66	2%	77	3%
	E	26	1%	26	1%	33	1%	52	2%	59	2%	52	2%
r_{fx}	SZ	0	0%	10	0%	8	0%	17	1%	2	0%	7	0%
	S	63	2%	74	2%	82	3%	82	3%	109	4%	96	3%
	I	52	2%	69	2%	18	1%	32	1%	44	1%	51	2%
	E	7	0%	14	0%	18	1%	25	1%	34	1%	22	1%
r_{cx}	SZ	4	0%	55	2%	23	1%	81	3%	2	0%	12	0%
	S	92	3%	191	6%	143	5%	189	6%	116	4%	142	5%
	I	78	3%	164	5%	33	1%	116	4%	50	2%	76	3%
	E	15	0%	69	2%	36	1%	100	3%	43	1%	53	2%

Note:

SZ – between 1 May 2005 and 31 July 2007, monetary tightening

S – between 1 August 2007 and 31 January 2010, general weakening

I – between 1 February 2010 and 30 November 2011, interim period

E – between 1 December 2011 and 31 December 2013, responses to the euro crisis

Source: own calculations

case of the forint), compared with the Swiss franc, where the number of extreme fluctuations is similar to that in the subprime period, due to the start of the franc's strengthening. In the period of responding to the euro crisis ("E"), these fluctuations dropped in every case, which means that the swap agreements and the CHF exchange rate ceiling, introduced in this period, were sufficient enough to calm the currency markets.

Naturally, it is worth exploring whether the crisis periods, as defined by us, are really different from each other. As shown in *Table 5*, daily extreme movements are significantly different in almost all periods – apart from the subprime and the interim periods in the case of the Swiss franc and the period of responding to the euro crisis in the case of the euro and the Japanese yen. It is an interesting finding that in this case, there is no significant difference between the methods used for specifying extreme returns.

The Dynamic Conditional Correlation (DCC) shows that exchange rates in Japanese yen were the closest to the results of *Stavárek* (2009), *Babetskaia–Kukharchuk et al.* (2008), and *Bubák et al.* (2011), showing strong comovements between the UDS and the Central and Eastern European currencies *(see Chart 3).* Calculated in Swiss franc, there were significant fluctuations in HUF-EUR and CHF-EUR comovements: these gradually decreased during the subprime crisis, then increased again in the interim period, followed by another decrease in the period of responding to the euro crisis. Calculated

Table 5

SIGNIFICANT DIFFERENCES IN THE TIME DISTRIBUTION OF THE EXAMINED CENTRAL AND EASTERN EUROPEAN CURRENCIES' EXTREME MOVEMENTS (APPLYING THE ANSARI–BRADLEY TEST)

	Denominator	CHF		EUR		JPY	
Method	Period	CZK	HUF	CZK	HUF	CZK	HUF
r_{vx}	SZ–S	1	1	1	1	1	1
	SZ–I	1	1	1	1	1	1
	SZ–E	1	0	1	1	1	1
	S–I	0	1	1	1	1	1
	S–E	1	1	1	1	1	1
	I–E	1	1	0	0	0	1
r_{fx}	SZ-S	1	1	1	1	1	1
	SZ–I	1	1	1	1	1	1
	SZ–E	1	0	1	0	1	1
	S–I	0	0	1	1	1	1
	S–E	1	1	1	1	1	1
	I–E	1	1	0	0	0	1
r_{cx}	SZ-S	1	1	1	1	1	1
	SZ–I	1	1	1	1	1	1
	SZ–E	1	1	1	1	1	1
	S–I	0	0	1	0	1	1
	S–E	1	1	1	1	1	1
	I–E	1	1	0	1	0	1

Note:

SZ – between 1 May 2005 and 31 July 2007, monetary tightening

S – between 1 August 2007 and 31 January 2010, general weakening

I – between 1 February 2010 and 30 November 2011, interim period

E – between 1 December 2011 and 31 December 2013, responses to the euro crisis

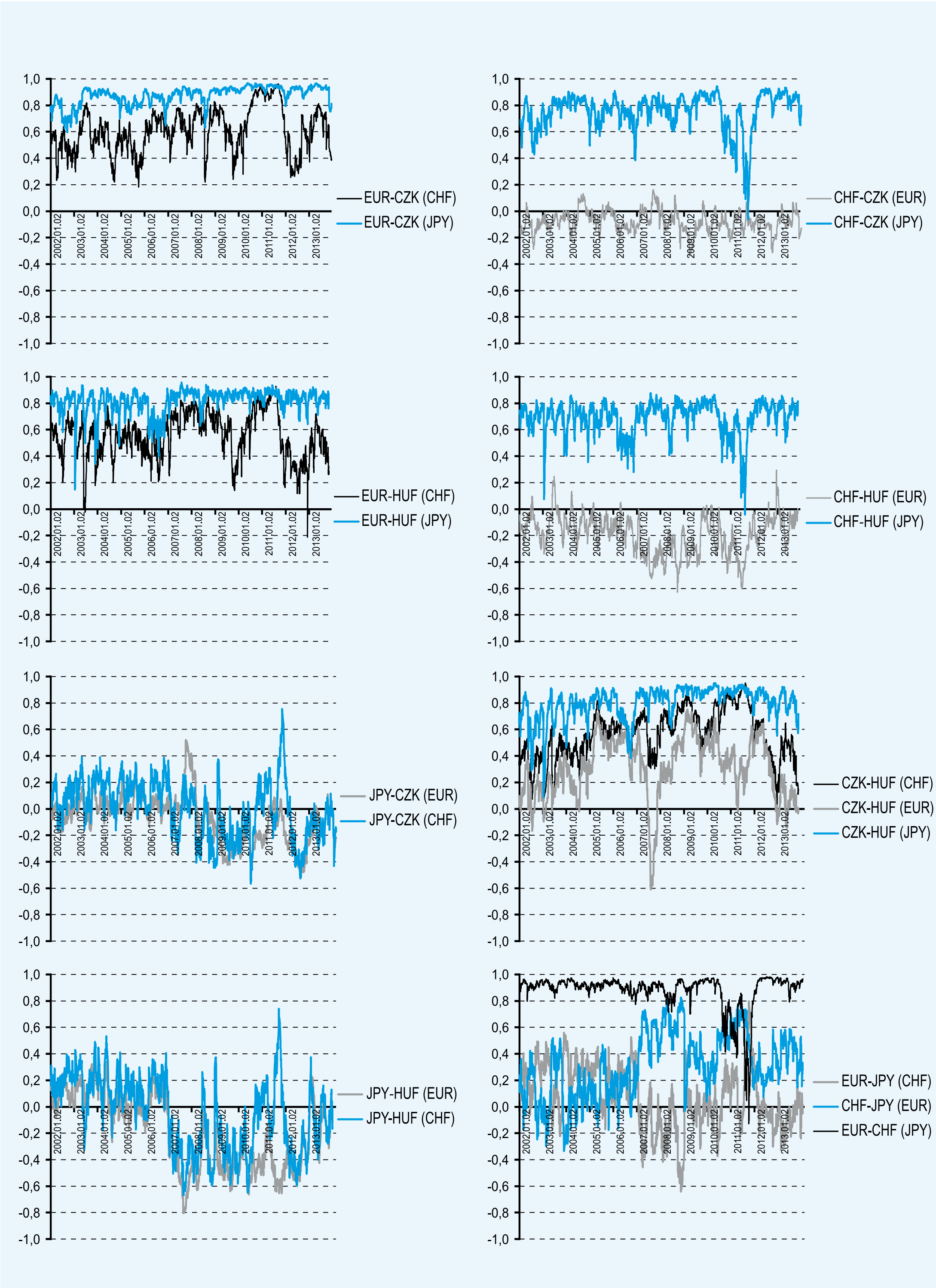
Source: own calculations

in Japanese yen, the comovement of European currencies and the Swiss franc was fairly strong even during the subprime crisis (0.6–0.8), followed by the abrupt strengthening of the Swiss franc in the interim period. It is noteworthy to see the correlation returning to the previous range afterwards. As expected, there is no significant comovement between the Japanese yen and the Central and Eastern European currencies.

In the first two phases of the crisis, the Czech koruna showed a significantly increasing correlation against the euro, while in the interim period, we see a significant reduction against the franc (calculated in yen) *(see Table 6)*. There is a significantly inverse, although weak comovement of the Japanese yen and the Czech koruna (calculated in euro). In the case of the forint, there are fewer significant differences in comovement, however, the euro–forint co-

Chart 3

DYNAMIC CONDITIONAL CORRELATION (DCC)



Source: own calculations

Table 6

SIGNIFICANT DIFFERENCES IN THE DYNAMIC CONDITIONAL CORRELATIONS (DCC) BETWEEN THE EXAMINED PERIODS (APPLYING THE ANSARI–BRADLEY TEST)

	Periods	EUR–CZK (CHF)	EUR–CZK (JPY)	CHF–CZK (EUR)	CHF–CZK (JPY)	JPY–CZK (CHF)	JPY–CZK (EUR)
A–B–test	SZ–S	1	1	1	1	0	1
	SZ–I	1	1	1	1	1	1
	SZ–E	1	1	0	1	1	1
	S–I	1	1	1	1	0	1
	S–E	1	1	1	1	1	1
	I–E	1	0	0	1	1	1
DCC–average	SZ	0.58	0.84	–0.07	0.74	0.09	0.02
	S	0.63	0.89	–0.08	0.80	–0.14	–0.10
	I	0.83	0.94	–0.09	0.62	0.08	–0.15
	E	0.55	0.91	–0.09	0.85	–0.19	–0.22

		EUR–CZK (CHF)	EUR–CZK (JPY)	CHF–CZK (EUR)	CHF–CZK (JPY)	JPY–CZK (CHF)	JPY–CZK (EUR)
A–B–test	SZ–S	1	1	1	0	1	1
	SZ–I	1	0	1	1	0	1
	SZ–E	0	1	0	1	1	0
	S–I	1	0	0	1	1	0
	S–E	1	0	1	0	0	1
	I–E	1	0	1	1	1	1
DCC–average	SZ	0.53	0.76	–0.18	0.65	0.04	–0.07
	S	0.64	0.86	–0.31	0.75	–0.32	–0.46
	I	0.71	0.87	–0.28	0.60	–0.03	–0.45
	E	0.41	0.83	–0.11	0.75	–0.21	–0.25

		EUR–CZK (CHF)	EUR–CZK (JPY)	CHF–CZK (EUR)	CHF–CZK (JPY)	JPY–CZK (CHF)	JPY–CZK (EUR)
A–B–test	SZ–S	1	1	0	1	0	1
	SZ–I	1	0	0	1	0	1
	SZ–E	1	1	1	1	1	1
	S–I	1	1	1	1	1	1
	S–E	0	0	0	1	1	1
	I–E	1	1	1	1	1	1
DCC–average	SZ	0.62	0.45	0.77	0.13	0.25	0.90
	S	0.64	0.34	0.87	–0.12	0.49	0.90
	I	0.79	0.37	0.90	0.15	0.52	0.67
	E	0.45	0.25	0.81	–0.06	0.35	0.94

Note:

SZ – between 1 May 2005 and 31 July 2007, monetary tightening

S –between 1 August 2007 and 31 January 2010, general weakening

I – between 1 February 2010 and 30 November 2011, interim period

E – between 1 December 2011 and 31 December 2013, responses to the euro crisis

Source: own calculations

movement (calculated in franc) also weakened recently. Similarly to the koruna, there was a substantial reduction in the CHF-HUF comovement as well (although it is still significant) in the interim period (calculated in yen). In the case of the Japanese yen, we see a much more inverse comovement. The comovement of the forint and the koruna was only weaker when calculated in euro, however, we should note that in the last crisis period, the correlation dropped in all three calculation variants. Regarding the key currencies, we found an interestingly strong comovement between the franc and the yen, while the euro–franc comovement, which could be interpreted as the test of our study, weakened precisely in the interim period (when the franc became stronger and the CHF exchange rate ceiling was introduced).

CONCLUSIONS

In summary, it can be stated that although it would seem logical to become indebted in a currency that exhibits historically strong comovements with our own currency and as a reserve currency is characterised by a low interest rate (as well as an abundance of liquidity and low inflation), such as the Swiss franc or the euro, don't do it. Weak stationarity, that is the stability of the first two moments, may still lead to the third and fourth moments presenting a time change, which manifests in an unusual degree of exchange rate changes through the increased kurtosis of exchange rates measured in francs. Due to the increased risk sensitivity highlighted by the crisis, compared to the Czech koruna, the forint showed more instances of extreme movement, most of which was extreme weakening. We see the fluctuating weakening of the strong pre-crisis comovement, while leading central banks tried their best to supply the market with FX liquidity. We must state, however, that although the colossal easing programmes of leading central banks managed to mitigate the pricing uncertainties of the currencies compared to the subprime and interim periods, it is still unclear what happens when these measures are discontinued. The temporary nature of the shock, caused by the sudden strengthening of the Swiss franc against the euro, is an interesting finding: following the announcement of the exchange rate ceiling, market comovements have returned to previous levels. Due to the historically strong correlation between the European currencies included in our analysis, the logical response to the crises should be the reduction in comovement (divergence) anyway, which we have proven. Nevertheless, the fundamental weakness of the forint was apparent: demonstrated by its weakening over the entire period, high kurtosis, higher number and more instances of extreme movement, and divergence. These characteristics were typically less prominent with the koruna, while in the case of key currencies, we found these to be incidental for the Swiss franc and the euro.

The forint showed extreme fluctuations, occurring with a frequency not seen before the crisis, against all three currencies used for foreign currency loans, while its historically strong comovement with European currencies reduced temporarily. Considering that we saw similar developments with the koruna, we think that it would be advisable to implement a targeted programme in Central and Eastern European countries, that are active in foreign currency lending, which would also include the asset and liability side consolidation of the banks. During the management of such a programme, it would be very useful to transfer supervision competencies to the central bank and also intensify community-level cooperation – following the example of swap agreements, used for half a decade to mitigate exchange rate volatility.

Notes

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2 http://www.nbp.pl/homen.aspx?c=/ascx/archen.ascx

3 http://www.ecb.europa.eu/press/pr/date/2010/html/pr101217.en.html

4 Act No. 6/1993 Coll., on the Czech National Bank; Hungary: Act 124 in 1999; Poland: Act on Financial Market Supervision of 2006, No. 157, item 1119)

5 http://www.admin.ch/ch/e/rs/9/951.11.en.pdf

6 http://www.japaneselawtranslation.go.jp/law/detail_main?id=92&vm=2&re=

7 http://www.boj.or.jp/en/announcements/release_2013/k130404a.pdf

8 For example, the policy interest rate increase is connected to the prognosis of weaker price stability in the medium-term.

9 http://www.federalreserve.gov/newsevents/reform_swaplines.html; http://www.ecb.europa.eu/press/pr/date/2007/html/pr071212.en.html

10 http://www.boj.or.jp/en/announcements/release_2008/un0809a.pdf

11 The list of central banks at times included the central banks of Norway, Australia, Mexico, Korea, Sweden and Denmark.

12 http://www.ecb.europa.eu/press/pr/date/2011/html/pr111130.en.html; http://www.boj.or.jp/en/announcements/release_2011/rel111221b.pdf

13 http://www.ecb.europa.eu/press/pr/date/2008/html/pr081015_1.en.html

14 http://www.ecb.europa.eu/press/pr/date/2010/html/pr101217.en.html

15 http://www.ecb.europa.eu/press/pr/date/2008/html/pr081016.en.html

16 http://www.ecb.europa.eu/press/pr/date/2008/html/pr081027.en.html

17 http://www.ecb.europa.eu/press/pr/date/2008/html/pr081121.en.html

18 http://www.imf.org/external/np/mfd/er/index.asp

19 Normal distribution of capital market returns would be asymptotically expected by the law of large numbers – assuming that exchange rate changes were caused by chance. We can resolve the fat-tailed return problem with Lévy's Pareto distribution assumption, that the sum of Pareto distributions measured over shorter time periods will also be a Pareto distribution, and with the increase in time intervals the distribution will approach the normal (Molnár, 2005, page 27). We should add, however, that in our current paper's sample, which consists of 3,035 elements and spans 12 years, normal distribution of returns did not appear.

20 The scale-free network's hierarchical structure does not change neither as a function of time nor the size of the network.

21 We used the World Bank's narrowest definition, see: http://go.worldbank.org/JIBDRK3YC0.

22 During the Ansari–Bradley test, we compare two independent samples of different lengths, assuming

that they are from the same probability distribution, in contrast with the alternative hypothesis, according to which they only have similar medians and forms, but distributions with different variances. If H=0, the two samples are similar, whereas if H=1, they are significantly different.

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