The Euro Crisis and Contagion among Central-East European Currencies

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Abstract
This paper aims to analyze the selected Czech, Hungarian and Polish currencies, through the statistical characteristics of Swiss franc and euro as well as the ECB's monetary policy to indicate shocks on these markets between 2002 and 2013. Contagions can be defined as increased comovements during crisis times – the selected time series were studied with two different approaches to identify extreme periods. Abundance of monetary easing decisions can be used as a viable sign for market misbehavior next to the low probability property of extreme exchange rate fluctuations. Common movements were calculated by dynamic conditional correlations (DCC GARCH).
Current paper compared these concepts, furthermore presented the patterns of contagions between the selected currencies. Contagion still appeared, but the well-known pre crisis convergence of Czech Koruna, Hungarian Forint and Polish Zloty decayed under the era of the Euro crises, causing enormous economic damage for the new member states.

Keywords: currency market, CEE, DCC GARCH, extreme interval, contagion
JEL codes: G15, G01, C32, E44, E58

1. Introduction

Currently, the Czech, Hungarian and Polish national banks follow an independent floating currency regime despite their future obligation of euro adoption and have the primary statutory objective of achieving and maintaining price stability. The upper mixture of harmonized monetary aim and floating currency regime is the product of the unique style of capitalism, characterized by underdeveloped capital markets, poor savings accumulation and over-concentrated banking systems (Farkas, 2011), resulting in substantial capital imports that accelerated the domestic credit booms in the pre-crisis era (Kovács, 2009, Árvai et al., 2009).

This paper aims to analyze the patterns of currency common movements applying Euro and Swiss franc as denominators - because it would be necessary to assess the nature of the risk of exchange rate to understand how foreign currency loans have been affected by the dynamics of currency market? Foreign currency loans (FCYLs) have a significant share in 18 EU member states, especially outside the euro-zone, while CHF loans had a significant share in Slovenia, Romania, Serbia, Croatia, Austria, Poland and Hungary (Yesin, 2013 page 221.).

Capital markets can be analyzed as a complex network, with extreme market events as tail property (Gabaix et al., 2003), which generates collective market behaviors (Bonanno et al., 2001). This study applies three methods for examining collective market behaviors on currency markets: our first approach based on the low probability of returns, while the second utilized heavy tailness phenomena as well as the last one used up monetary easing or tightening decisions of the European Central Bank (ECB).

The relevance of economics of these findings are supported by the phenomena of current the foreign currency loan crisis in Hungary, due to the Euro-crisis triggered Swiss franc appreciation on the medium run, as well as the obligational euro-adoption on the long run.

1.1 Definitions and Data

The scope of current paper requires precise definitions for extreme events related phenomena like extreme and normal returns, subsets of collective behavior such as contagion, divergence and interdependence among the complex system of capital markets.

To understand the nature of capital markets, it is necessary to choose a reliable model, which allows extreme jumps and collective behaviors. A more heterogeneous and hierarchic market should be assumed than it is suggested by the efficient market hypothesis. Therefore the null hypothesis of efficient markets will be tested against the alternative hypothesis of complex markets – in his famous article, Fama (1970) requires the lack of autocorrelation and normal distributed returns for efficiency on the pages 384 and 399.

To model the network structure of one market *(n)* (1) it is necessary to define the actors *(a)*, their interactions *(c)*, and the shape of the network *(sh)*:

$$n(a, c, sh). \qquad (1)$$

The mainstream model of efficient markets (2) has the following structure:

$$r_n(a_r, sh_r, s_b, h_{e-k}), \qquad (2)$$

where r_n denotes the normal distributed returns, while a_r signs rational actors according to Simon (1955), s_{hr} is random networks by Erdős and Rényi (1960), s_b random-walk of prices, as well as h_{e-k} is the sign of market efficiency. The Erdős-Rényi random networks are capable to model competitive and efficient markets with dynamic recombination and fast information propagation, but they are unable to describe preferential connectivity (Watts and Strogatz, 1998). From statistic view, it involves the requirements of normal distributed, homoscedastic and not autocorrelated returns.

To describe capital markets on a more realistic base, extreme jumps and forms of collective behaviors must be involved. An extreme event can be defined as a $w_x \in W$ event for a W stochastic variable with a $w_x >> w_n$ or $w_x << w_n$ significant higher impact than the expected, in a limited time and space with a $p(w_x) << p(w_n)$ significant lower probability than the expected, providing a uniqueness (Jentsch et al., 2006). The dynamic property of extreme events is related to their definition – "power-laws represent scale-free systems" as Jentsch et al. (2006) mentions on page 4 of their chapter. Extreme events are not generated randomly, they occur in systems with complex dynamics – which are far from equilibrium and dominated by the system's variability and collective effects (Kantz et al., 2006). Current paper sorts capital market returns in two complementary subsets: extreme and normal returns – according to the definition of extreme events.

Definition: normal returns r_n have a higher probability than 5% or fitting well on the projected theoretical normal distribution. This definition suggests that the sub sample of normal returns has a near to a level 3 kurtosis (fourth moment), which property will be useful in future to test the results of the separation.

Definition: extreme return r_x can be defined as an extreme event on capital markets – they both have really low probability $p(r_x) << p(r_n)$ and high impact on the tails $r_{x-} << r_n << r_{x+}$ - this definition is able to meet the requirements by Jiawei and Micheline (2004) about extreme values as well. Two approaches were applied in this study to capture extreme returns: while the first based on the low probability, the second utilized the fat tailed distribution property.

Definition: improbable return r_{vx} (3) refers to those returns, which are under the 5% probability threshold. This approach can be rigid on the third and fourth moments.

$$p_{r_{vx}} < 5\% \qquad (3)$$

Definition: fat tailed return r_{fx} (4) is the result of an extreme change on the m_j market, causing fat tails for the r^{m_j} return's probability distribution. This occurrence is in connection with the skewness of the distribution, while their probability and value differ harshly from the *E(r)* expected return. It means that fat tailed returns can be selected via the difference on the tails between the theoretical normal distribution and the empirical data – utilizing latter "S-shaped" form on QQ plots.

$$r_{fx+} \gg E(r), \text{ or } E(r) \gg r_{fx-}, \text{ where } p_{r_{fx}} \ll p_{E(r)} \qquad (4)$$

Both improbable and fat tailed returns were referred as extreme returns in the paper.

Definition: capital market shock captures the ability of returns, to fluctuate between the r_n normal subset and the r_x extreme subset. The $r_{n/x} \neq 0$ indicates the existence of this transition between both subsets (5), as well as the $r_{n/x}=0$ indicates the absence of this – as a sign of an efficient market only with normal returns (6):

$$r_{n/x}^{m_i} \neq 0 \;\rightarrow r^{m_i} = \begin{cases} r_n^{m_i} \\ r_x^{m_i}, \end{cases} \tag{5}$$

$$r_{n/x}^{m_i} = 0 \;\rightarrow\; r^{m_i} = r_n^{m_i}. \tag{6}$$

If extreme returns represent a higher mass than it could be expected from normal distribution, capital market should be modeled as a complex system – it is suggested by the dynamic properties of extreme events (7):

$$r_{n/x}(a_{kr}, sh_s, s_{a-h}, h_{gy}), \tag{7}$$

where $r_{n/x}$ denotes shock on capital markets due to the fat-tailed distribution of returns, a_{kr} signs bounded rational actors (Arrow, 1986, Vriend, 1996), sh_s means scale-free network, s_{a-h} point on autocorrelated and heteroskedastic time series, as well as h_{gy} denotes the lack of efficiency. Scale-free complex networks were described by Barabási and Albert (1999), what is able to explain internal heterogeneity through preferential connections which could be responsible for spontaneous synchronisations ("large cooperative phenomena") or phase transitions as structural collapse of the former market hierarchy. These systems are far from equilibrium as self-organized criticality (SOC) describes – therefore extreme events are inherent properties of the system and indicated by power law distribution. The ability of scale invariant complex networks to model capital markets was evaluated by Vitali et al. (2011) on global and by Benedek et al. (2007) on Hungarian scale.

Bonanno et al. (2001) summarizes the three main statistical phenomena for a complex capital market: time series both have short and long range memories with asymptotic stationarity, high sectoral intraday cross-correlation as well as collective market behavior emerges during extreme market events. Later property is important from the aspect of the current paper. Collective market behaviors have three well known versions in the literature: contagion, divergence and interdependence. These phenomena related to how the market mood changes about the homogeneity or heterogeneity categorization of different assets or countries.

A three level definition was published by the World Bank for contagion effect to capture the different dynamics on real economies and capital markets. The very restrictive definition[1] for contagion focuses on cross-country correlations increase during "crisis times" relative to correlations during "tranquil times".

Definition: contagion (8) occurs between $m_k m_j$ markets when the $\rho^{m_k m_j}$cross-market correlation becomes significantly higher due to a shock derived from one market ($r_{n/x}^{m}$) spreading to others or as a result of other external factors (Forbes and Rigobon, 2002, Campbell et al., 2002, Bekaert et al., 2005):

$$r_{n/x}^{m_i} \neq 0 \;\rightarrow \rho_n^{m_k m_j} < \rho_x^{m_k m_j}, \tag{8}$$

Definition: interdependence (9) occurs between $m_k m_j$ markets when the $\rho^{m_k m_j}$ cross-market correlation is not significantly different, but the level of correlation is consistently high (Forbes and Rigobon, 2002):

$$r_{n/x}^{m_i} \neq 0 \;\rightarrow \rho_n^{m_k m_j} \approx \rho_x^{m_k m_j}, \tag{9}$$

Definition: divergence (10) occurs between $m_k m_j$ markets when the $\rho^{m_k m_j}$ cross-market correlation becomes significantly lower due to a shock derived from one market ($r_{n/x}^{m}$) spreading to others or as a result of other external factors (Bearce, 2002a):

$$r_{n/x}^{m_i} \neq 0 \;\rightarrow \rho_n^{m_k m_j} > \rho_x^{m_k m_j} \quad , \tag{10}$$

Definition: the autonomy of the monetary policy is an ability of central banks to set prime rates according to macroeconomic conditions – it can be viewed as a range of decisions (Bearce, 2002b). Autonomy is related to the independence from the monetary policies in the key currency areas and can be reduced by the degree of monetary interdependence, which is based on trade relationships and cross-border production chains (Plümper and Troeger, 2008). Global liquidity is able to limit this autonomy by increasing the vulnerabilities of a financial system through substantial mismatches across currencies, maturities and countries, while the supply of global liquidity stems from one or more "core countries" (BIS, 2011). This definition is necessary, because the upper forms of collective behaviors

[1] See: http://go.worldbank.org/JIBDRK3YC0, cited also by Forbes and Rigobon (2002).

are able to hinder monetary autonomy due to their impact on the external debt of the public and private sectors as well as on price stability.

Current paper tested the time series of the free floating Czech Koruna (CZK), Euro (EUR), Hungarian Forint (HUF), Polish Zloty (PLN), Swiss franc (CHF) and US Dollar (USD), on a daily basis between January 1. 2002 and July 16. 2013. The database of the Polish National Bank was the source of the data[2]. Currencies were denominated both in CHF and EUR for different reasons – usage of CHF supported the analysis of foreign currency loan driven external imbalances while application of EUR presented the ERM2 readiness for CEE countries to study, how market shocks are able to break former common movement patterns. Occurrence of contagions and divergences are the indicators, how market forces are affecting these issues.

2. Theoretical background

After the above-mentioned collection of required definitions to capture inherit capital market dynamics, this chapter focuses on two theoretical aspects of monetary policy: at first it is necessary to study the monetary tightening and easing decisions of the ECB respectively to describe foreign currency loan indicated external vulnerabilities.

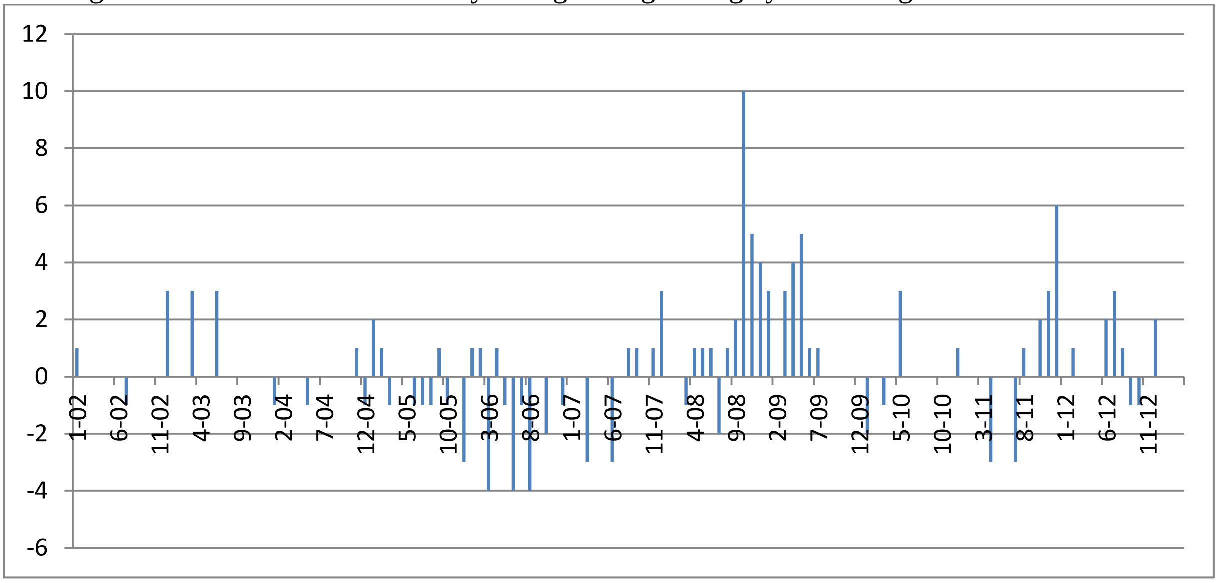
2.1 Monetary policy of the ECB

The primary objective of the ESCB is to achieve and maintain price stability according to the (1) 127§ Treaties and the Statute of the ESCB, while financial stability is crucial because transmission of monetary policy can be hampered when massive financial turbulences occur (ECB, 2011).

The monetary policy instruments used by the Eurosystem in 2011 comprised open market operations, such as main refinancing operations (MROs), longer-term refinancing operations (LTROs) and fine-tuning operations, as well as standing facilities and minimum reserve requirements. The Eurosystem also made use of non-standard measures, including the second covered bond purchase programme and the Securities Markets Programme. Monetary policy decisions were analyzed between January 2002 and March 2013 according to the Annual Reports of the ECB. Kiss and Kosztopulosz (2012, 2013) studied the ECB-CEE interactions in particulars under the sub-prime crisis, but current paper focuses on the impacts of monetary easing and tightening in a more detailed view. It was hard to define the end of pre-crisis era, due to the fear of increasing raw material prices – which resulted increased prime rates in August 2008 contrary to former liquidity widening actions in 2007 q3. Sub-prime crisis became hard after the fall of Lehman Brothers, leading a zero bound rate in the euro-zone, swap agreements with leading central banks and euro liquidity programs for CEE national banks. An interim phase appeared after the sub-prime crisis, with a transition from banking to a sovereign default crisis. Liquidity dried up on emerging euro-zone bond markets in 2011 q1 after the suspension of the rating threshold for debt instruments of the Irish government, and the changes in eligibility of debt instruments issued or guaranteed by the Portuguese government. Greek debt instruments were not accepted as collaterals in February 2012, but this provision was cancelled and these securities were accepted without any thresholds in March 2012. The Governing Council of the ECB decided to decrease the interest rate on the main refinancing operations by 25 basis points to 0.75% in July 2012. Measures were addressed the severe malfunctions in the price formation process in the bond markets of euro area countries, even though outright open market operations (ECB, 2002-2012).

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

Figure 1: Decisions about monetary easing and tightening by Governing Council of the ECB



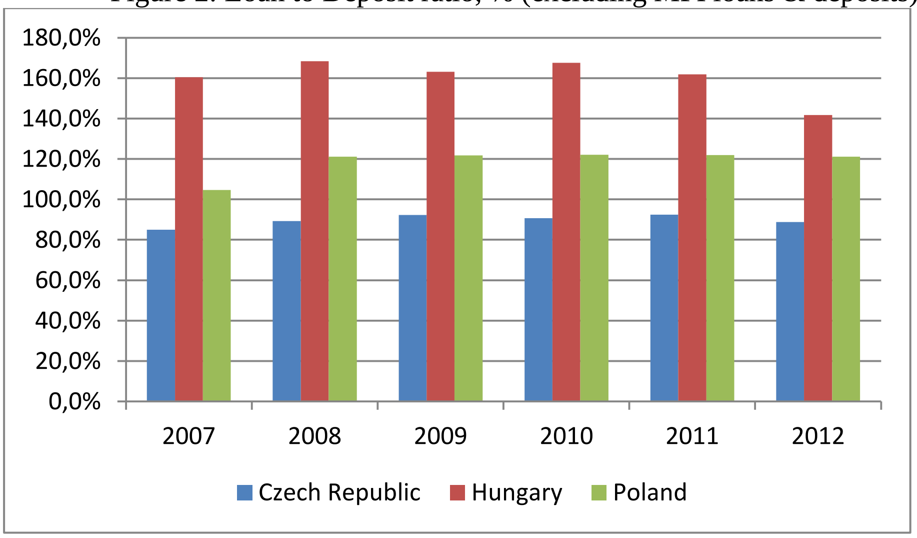
Source: author's calculations, based on ECB (2002-2012)

Figure 1 presents the Governing Council's reactions about monetary tightening and easing according to the yearly Annual Reports of the ECB. Both open market operations (like main refinancing operations (MROs), longer-term refinancing operations (LTROs), non-standard measures (for example second covered bond purchase programme or Securities Markets Programme) and fine-tuning operations), as well as standing facilities and minimum reserve requirements. This result could be useful to identify two main periods in the monetary policy of the ECB: the tightening between March 2005 and July 2007 respectively an easing period after August 2007 – including the sub-prime crisis (August 2007-January 2010) and the euro-crisis (August 2011-July 2013).

2.2 Foreign currency loans

FCYLs serve as vulnerability for two main reasons: on the one hand, exchange rate risk between the national currency and the CHF erodes the quality of the credits so the solvency of the banks. On the other hand, the credit boom in the private sector was supported by external capital in the banking sector: loan-to-deposit ratios exceeded the level of 100% in our sample (except Czech Republic, see figure 2), weakening be banks liquidity position (Kovács, 2009, EBF, 2012).

Figure 2: Loan to Deposit ratio, % (excluding MFI loans & deposits)



Source: European Banking Federation (2012)

This problem affected mostly Hungary, Poland and Austria, but the other CEE countries could suffer the spillover effects – and a constant demand for foreign liquidity. Monetary policy has to support its banking system under turbulent time trough foreign liquidity programmes. To avoid the decrease of currency reserves, swap lines or repo agreements with another central banks were applied in 2008-2009 as well as IMF credit programs (BIS, 2011, Antal and Gereben, 2011). But one question remains: provides the former division of labor between financial supervision authorities and central banks suitable risk assessment both for solvency and liquidity crisis under the current circumstances? There was an institutional path since the nineties to create integrated market regulation instead of sectorial regulatory institutions (Colin and Zimková, 2009), and now there is a trend to integrate supervisions within the central banks (MNB, 2013).

3. Methodology

Contagions and divergences between currencies were tested trough three steps: market efficiency was tested at first, then extreme trading days and periods were cleared, as well as dynamic conditional correlations were calculated. Functions of MFE and UCSD Matlab toolboxes were applied.

Returns on an efficient capital market should be normal distributed and non autocorrelated as Fama (1970) requires in his paper on pages 384 and 399. Returns were logarithmic differentials of the currency rates. The definition of contagion and divergence requires conditional correlations as well, which can be biased by heteroscedasticity (Forbes and Rigobon, 2002). Jarque-Berra test was used to study the normal distribution, what is based on the third and fourth moments of the returns. To test the decay of heteroscedasticity and autocorrelation, ARCH-LM and Ljung-Box tests were utilized.

Under the assumption of weak market efficiency, time series are mostly biased by autocorrelation and heteroscedasticity due to the fat tailed distributions and volatility clustering. This paper follows the steps by Cappeiello et al. (2006) to fit dynamic conditional correlation on the time series: heteroscedasticity had to be ruled out via univariate Generalized Autoregression and Heteroscedasticity (GARCH) models to manage unique volatility properties (see Stavárek, 2010), then Engle’s (2002) Dynamic Conditional Correlation (DCC) were fitted on the homoscedastic residuals. For the univariate step, the Asymmetric Power GARCH (APARCH)[3] model is the most powerful tool to handle the bias of heteroscedasticity due to the asymmetric, fat-tailed assumptions of the distribution (Ding et al., 1993). Three parameters of APARCH have to be defined, “p” and “q” determines the lag number of residuals and volatility, while “o” is a non-negative scalar integer representing the number of asymmetric innovations. Further advantage of the APARCH model is the flexibility – it is easy to convert both on GJR GARCH and TARCH as well as the basic GARCH form too. The lag length was optimized on a 1-to-4 scale and selected according to the estimation’s Akaike Information Criteria (AIC). Dynamic conditional correlations were fitted on the homoscedastic standardized residuals of the GARCH models during the multivariate case.

Extreme trading days were defined trough two ways: improbable returns were indicated, when their probability was less than 5% according to the empirical cumulative distribution function. Fat tailed returns were selected on the base logic of a QQ plot. QQ plots are common tools of visualizing the normal distribution of the time series with a straight line which represents the normal distribution and dots of the empirical distribution. Normal distribution of the empirical data is observable, if dots are fitting on the line, but most financial data has an “S” shape on the QQ plot – suggesting a power-law distribution and fat-tails (Clauset el al., 2007). Relying on the definition of QQ plots by Deutsch (2002, page 690-691), the above separation can be expressed in the following (11) way:

$X_i = \phi_1^{-1}(P_i) = \phi_1^{-1}(i/T)$ for all $i<T$, therefore,

$$\begin{aligned} r_n &\approx \mu_2 + \sigma_2 X_i, \\ r_{fx}^{+} &> \mu_2 + \sigma_2 X_i, \\ r_{fx}^{-} &< \mu_2 + \sigma_2 X_i, \end{aligned} \qquad (11)$$

[3] The estimation based on the UCSD toolbox, developed by Kevin Sheppard: http://www.kevinsheppard.com/wiki/UCSD_GARCH

where X_i denotes the theoretical empirical standard normal distribution, which is represented in the QQ plot by a line with $\mu_2 + \sigma_2 X_i$ slope. Therefore it is reasonable to define the tails trough QQ plot, where the turning point of extremity is defined as the first empirical data in the lower quartile right from the normality line on the positive side and left from the normality line on the negative side. The entire time series can be divided (12) into extreme and normal subsets according to the above definitions:

$$r\begin{cases} r_{fx}\begin{cases} r_{fx}^{+}: r_{empirical,l} > \mathrm{r}_{\mathrm{theoretical}_{\mathrm{normal}},\mathrm{l}} \\ r_{fx}^{-}: r_{empirical,i} < \mathrm{r}_{\mathrm{theoretical}_{\mathrm{normal}},\mathrm{i}} \end{cases} \\ r_n: \mathrm{r}_{\mathrm{theoretical}_{\mathrm{normal}},\mathrm{i}} < r_{empirical,k} < \mathrm{r}_{\mathrm{theoretical}_{\mathrm{normál}},\mathrm{l}} \end{cases} \quad (12)$$

where $r_{empirical,i}$ is the ith element of the empirical distribution and the $r_{theoretical_{normal},i}$ denotes the projected normal distribution, $i<k<l$.

This study applies DCC-GARCH[4], to analyze the daily common movements of the selected markets. Cross market correlation is compared both with Ansari-Bradley and two-sided t-test, because the variance test is not based on the assumption of normal distribution – as happens in the case of the widely used t-tests. Contagions, divergences and interdependences initiated by one market's extreme days have to be detected for 10 inter-market correlations. First, it is necessary to decide between interdependence (nonsignificant changes in correlations) and significant correlation changes (such as divergence and contagion) – this could be expressed by the overall weight of significantly different correlations (14):

$$\frac{\sum(s_{m_1m_2}, s_{m_1m_3}, \dots, s_{m_jm_k}, \dots, s_{m_{n-1}m_n})}{N}\begin{cases} > 50\%, where\ is\ contagion\ or\ divergence \\ \leq 50\%, where\ is\ interdependence \end{cases}, \quad (14)$$

where $s = \begin{cases} 1, when\ correlations\ are\ significant\ different \\ 0, when\ correlations\ are\ nonsignificant\ different \end{cases}$, N denotes the number of involved market pairs. Contagions are characterised by significantly higher correlations and divergences are characterised by significantly lower correlations according to the definitions (11). To select between these two forms, the following algorithm was used:

$$g = \begin{cases} 1, if\ (\rho_{na} = \begin{cases} 0, if s = 0 \\ \rho_n, if s = 1 \end{cases} < \rho_{xa} = \begin{cases} 0, if s = 0 \\ \rho_x, if s = 1 \end{cases}) \\ 0, if\ (\rho_{na} = \begin{cases} 0, if s = 0 \\ \rho_n, if s = 1 \end{cases} \geq \rho_{xa} = \begin{cases} 0, if s = 0 \\ \rho_x, if s = 1 \end{cases}) \end{cases},$$

than $\frac{\sum(g_{m_1m_2}, g_{m_1m_3}, \dots, g_{m_jm_k}, \dots, g_{m_{n-1}m_n})}{N}\begin{cases} > 50\%, where\ is\ contagion \\ \leq 50\%, where\ is\ divergence \end{cases}$. (11)

Thus the contagion was expressed by weighting against the entire set of correlations, which is a strict rule.

4. Results

The null hypothesis of efficient markets was rejected (see table 1) due to the lack of normal distributed returns as the zero p values of Jarque-Bera test suggests, despite only the Hungarian forint seemed to be autocorrelated[5]. Fat tailness was indicated by excess kurtosis, where CHF denomination provided higher mass of extreme returns. Heteroscedasticity appeared on the entire sample as ARCH-LM test suggested. Logarithmic differentials as returns were covariance stationary according to the augmented Dickey Fuller (ADF) test with auto lag selection. Results of fat tailed heteroscedastic returns supported the idea of compex markets and motivated to focus deeper on CHF denomination.

Table 1: Asymmetry, kurtosis and P values of the descriptive statistics

	skewness	kurtosis	Jarque-Berra	Ljung Box*	ARCH-LM*	ADF
USD/EUR	-0,1205	5,0330	0,0000	0,8107	0,8850***	0,0000
CHF/EUR	-2,2602	56,8721	0,0000	0,1009	0,6475***	0,0000

[4]The estimation based on the Oxford MFE toolbox, developed by Kevin Sheppard: http://www.kevinsheppard.com/wiki/MFE_Toolbox

[5] Currencies are often non autocorrelated contrary to stock and bond markets as Kiss and Kosztopulosz (2012) suggests.

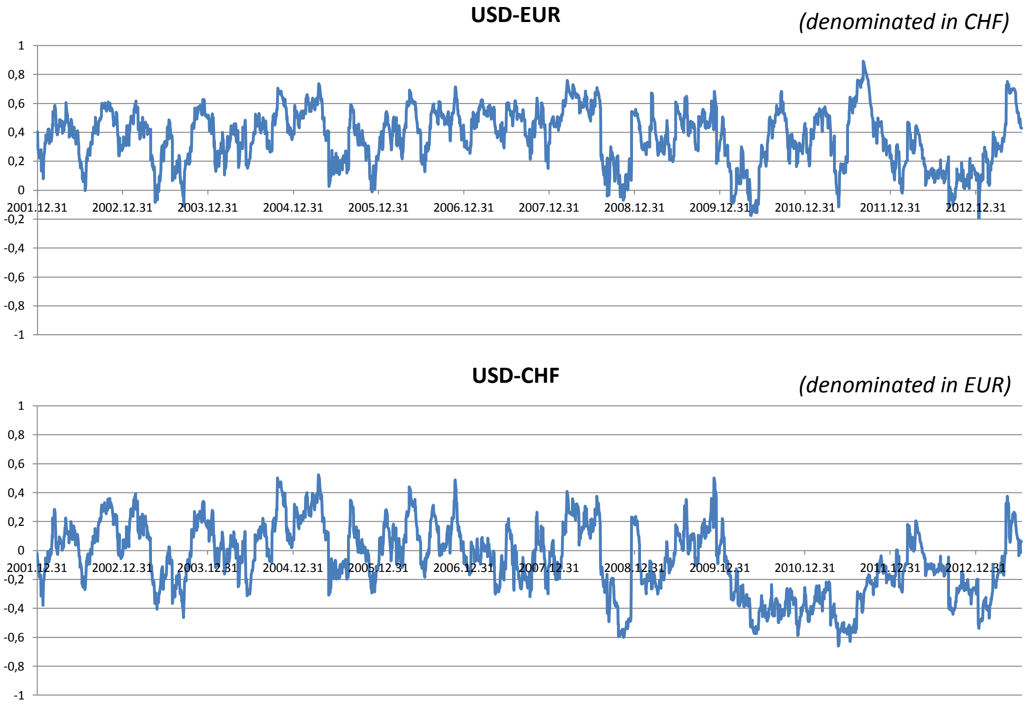
CZK/EUR	-0,0690	8,5589	0,0000	0,1351	0,4521***	0,0000
HUF/EUR	0,0262	11,1366	0,0000	0,0012**	0,0670***	0,0000
PLN/EUR	0,6258	10,8723	0,0000	0,0143	0,3009***	0,0000
USD/CHF	0,2088	11,6025	0,0000	0,3703	0,5820***	0,0000
EUR/CHF	2,2602	56,8721	0,0000	0,1009	0,6475***	0,0000
CZK/CHF	0,9281	19,5116	0,0000	0,9151	0,9723***	0,0000
HUF/CHF	-0,0262	11,1366	0,0000	0,0012**	0,0670***	0,0000
PLN/CHF	-0,0061	12,9254	0,0000	0,0105	0,2365***	0,0000

*: the second lag, **: autocorrelation, ***: heteroscedasticity

Source: author's calculations

The parameters of univariate GARCH models are not detailed in this paper, because the same methodology was applied on a similar data by Kiss and Kosztopulosz (2012). Common movement between the key currencies – as a validation indicator – seemed to be medium only in the USD/CHF-EUR/CHF case, due to the safe heaven role of the Swiss franc (see figure 2).

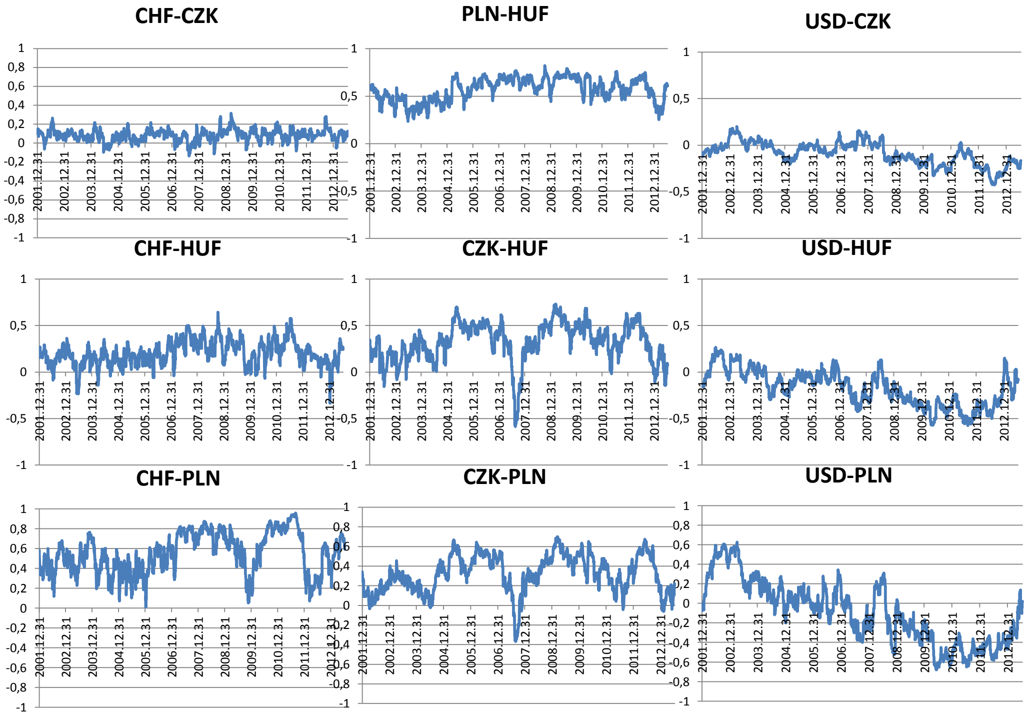
Figure 2: Dynamic conditional correlation between the key currencies



Source: author's calculations

The USD currency pairs were used as control variables on figure 3, because their poor correlation with the CEE currencies is a well-known fact (Bubák et al., 2011, Stavárek, 2009, Babetskaia-Kukharchuk et al., 2008). CEE currencies followed a medium common movement which decreased after a temporary increase during the Euro-crisis. Only the PLN/EUR-CHF/EUR currency pairs had stronger correlation – but it weakened both in the era of subprime crisis as well as under the euro-crisis. The same dynamics occurred in the case of the HUF/EUR-CHF/EUR pairs, but on a weaker scale. Latter two results indicate bad news either for the creditors or the debtors of CHF based FCYLs. Consequently, this fluctuation provides a decreasing debtor quality – breaking the solvency of the banking system.

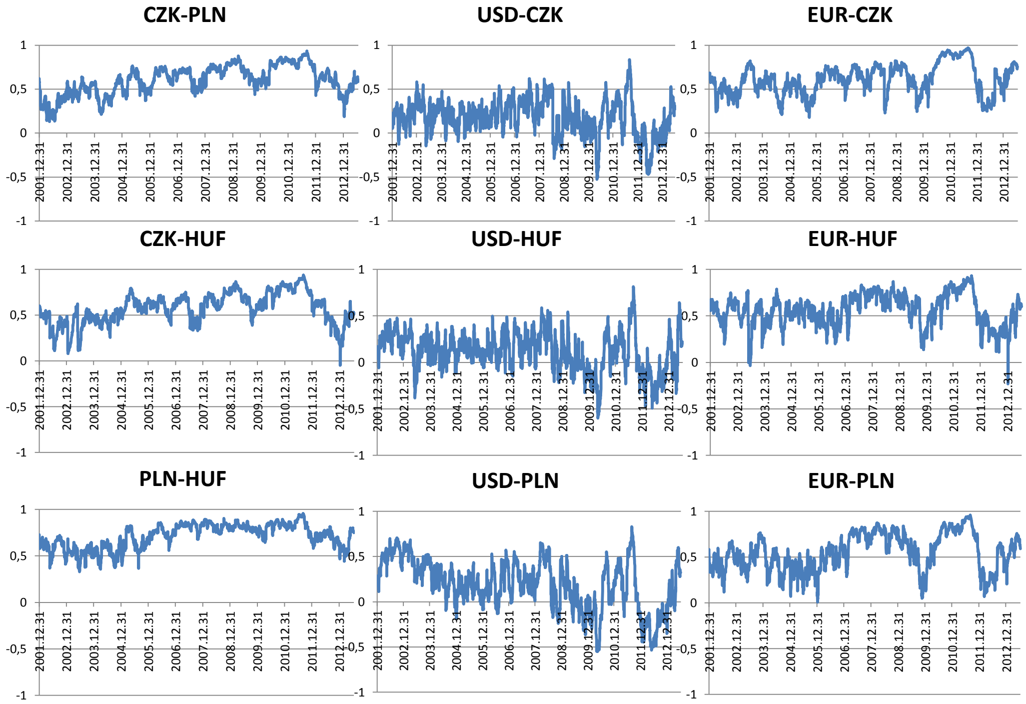
Figure 3: Dynamic conditional correlation on a daily basis – currencies with EUR denomination



Source: author's calculations

The pre-crisis convergence among CEE currencies and with euro decreased under the sub-prime and euro-crises (see figure 4), presenting a novelty compared with the literature (see Stavárek, 2009). This result suggested the idea to study, how common movements were changed under the different monetary environments.

Figure 4: Dynamic conditional correlation on a daily basis – currencies with CHF denomination



Source: author's calculations

Correlation had different dynamics in table 2, when they were studied according to separation by the ECB's monetary environment. Both the results of t-tests and Ansary-Bradley tests suggesting, that decisions of the ECB added reliable input to define different collective behaviors on currency markets. Pre crisis era with monetary smooth tightening (March 2005-July 2007) and crisis era (with two monetary easing and an interim period) between August 2007 and July 2013 were compared in the first prism. The difference of the correlations between the periods clearly indicates contagion in CEE, while the control variable USD pairs indicated divergence. The result of intense common movement under turbulent time enhanced our former statement about the increased currency convergence in the sample. A more precise selection was made in the second prism, with a comparison of pre-crisis and subprime crisis (August 2007-January 2010) eras with the similar result.

Well, upper patterns were changing under the comparisons of pre-crisis and the euro-crisis (August 2011-July 2013) as well as sub-prime and euro-crisis periods, suggesting divergence in CEE. This inconsistence supports the idea, that both the banks and their clients found themselves in unusual situation due to currency market dynamics under the euro-crisis. The difference between the sub-prime crisis and euro-crisis is remarkable, because only the latter resulted had taken an end of stable CHF course.

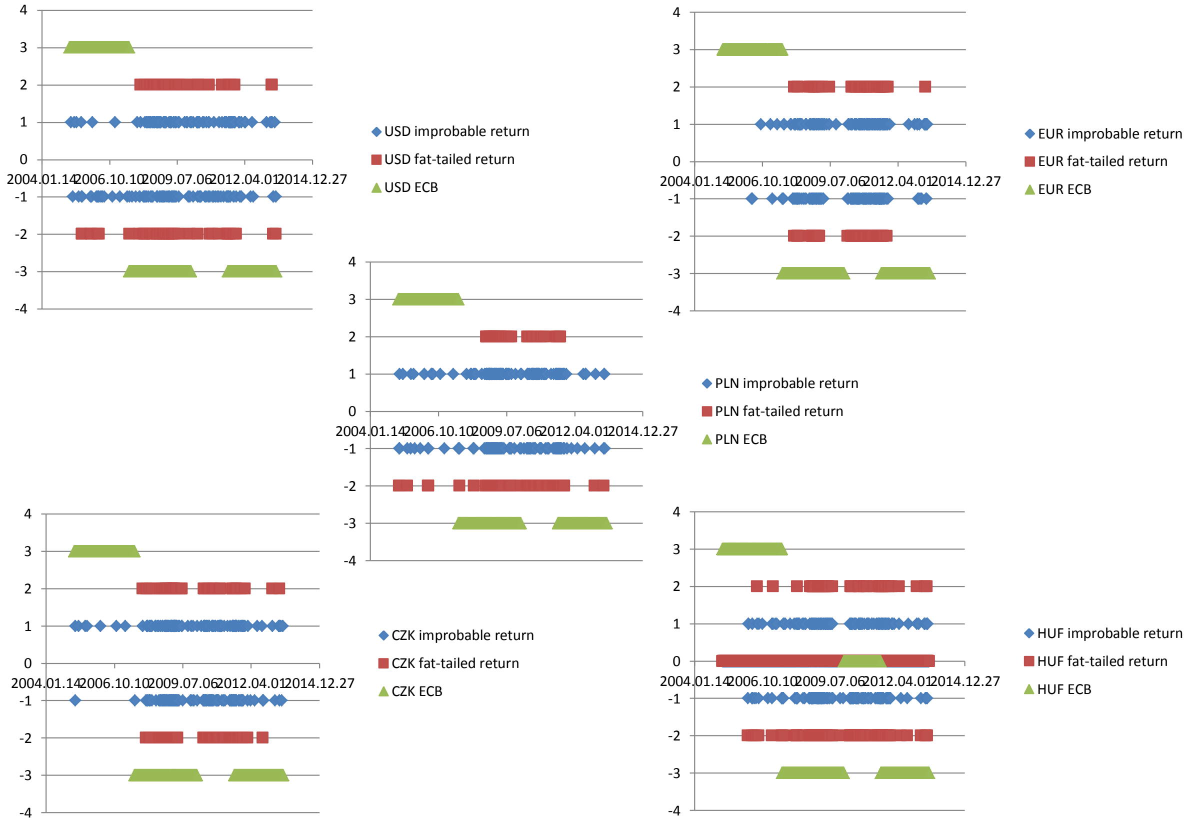
Table 2: Different correlations under tightening (T) and easing (E) ECB monetary policy environment – currencies with CHF denomination

currency pairs		USD-CHF	USD-CZK	USD-PLN	USD-HUF	CHF-CZK	CHF-PLN	CHF-HUF	CZK-PLN	CZK-HUF	PLN-HUF	control		CEE	
2005-2007 vs. 2007-2013	t-test	1	1	1	1	1	1	1	1	1	1	100%	*	100%	*
	mean T	0,417	0,233	0,198	0,157	0,580	0,484	0,527	0,634	0,618	0,734				
	mean E	0,343	0,146	0,083	0,067	0,668	0,629	0,598	0,682	0,639	0,782				
	changes	-1	-1	-1	-1	1	1	1	1	1	1	-100%	***	100%	**
	var T	0,025	0,015	0,025	0,017	0,019	0,030	0,016	0,008	0,007	0,009				
	var E	0,048	0,063	0,091	0,065	0,035	0,045	0,039	0,018	0,028	0,008				
	A-B test	1	1	1	1	1	1	1	1	1	0	100%	*	83%	*
2005-2007 vs. 2007-2010	t-test	0	1	1	1	1	1	1	1	1	1	75%	*	100%	*
	mean T	0,417	0,233	0,198	0,157	0,580	0,484	0,527	0,634	0,618	0,734				
	mean E	0,419	0,205	0,163	0,129	0,628	0,659	0,648	0,681	0,637	0,815				
	changes	0	-1	-1	-1	1	1	1	1	1	1	-75%	***	100%	**
	var T	0,025	0,015	0,025	0,017	0,019	0,030	0,016	0,008	0,007	0,009				
	var E	0,032	0,044	0,058	0,042	0,020	0,032	0,023	0,011	0,017	0,002				
	A-B test	0	1	1	1	1	1	1	1	1	1	75%	*	100%	*
2005-2007 vs. 2011-2013	t-test	1	1	1	1	1	1	1	0	1	1	100%	*	83%	*
	mean T	0,417	0,233	0,198	0,157	0,580	0,484	0,527	0,634	0,618	0,734				
	mean E	0,293	0,058	-0,019	0,008	0,604	0,516	0,456	0,608	0,545	0,706				
	changes	-1	-1	-1	-1	1	1	-1	0	-1	-1	-100%	***	-17%	***
	var T	0,025	0,015	0,025	0,017	0,019	0,030	0,016	0,008	0,007	0,009				
	var E	0,056	0,082	0,119	0,084	0,045	0,053	0,039	0,023	0,039	0,011				
	A-B test	1	1	1	1	1	1	1	1	1	1	100%	*	100%	*
2007-2010 vs. 2011-2013	t-test	1	1	1	1	0	1	1	1	1	1	100%	*	83%	*
	mean T	0,419	0,205	0,163	0,129	0,628	0,659	0,648	0,681	0,637	0,815				
	mean E	0,293	0,058	-0,019	0,008	0,604	0,516	0,456	0,608	0,545	0,706				
	changes	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-100%	***	-83%	***
	var T	0,032	0,044	0,058	0,042	0,020	0,032	0,023	0,011	0,017	0,002				
	var E	0,056	0,082	0,119	0,084	0,045	0,053	0,039	0,023	0,039	0,011				
	A-B test	1	1	1	1	1	1	1	1	1	1	100%	*	100%	*

*: collective behavior, **: contagion, ***: divergence
Source: author's calculations

Extreme trading days were expressed with two methods like improbable (with a value 1 under extreme weakening and -1 under extreme appreciation on figure 5) and fat tailed returns (with a value 2 under extreme weakening and -2 under extreme appreciation). This setup makes easier to compare the differences between these approaches: improbable returns representing the bigger set of returns where a Value-at-Risk system could close the position, while fat tailed returns represent special cases where ordinary assumptions like normal distributed returns are out of order. Monetary easing (with a value -3) and tightening (represented by 3) periods were compared with this data. The result is clear: extreme trading days concentrated under the crisis periods – regardless to the interim period between subprime and euro-crisis. Monetary responses and currency fluctuations overlapped under sub-prime crisis, contrary to the euro-crisis, which had a strong impact on the currency market, taking an end of the previous abundance of fat tailed extreme jumps – except Hungary. This means, that ECB was able to push back pricing uncertainties on a lower level: returns are not fat tailed, only under the 5% probability threshold.

Figure 5: Distribution of extreme trading days and monetary environment – currencies with CHF denomination



Source: author's calculations

These results can be interpreted as the following: bursting asset bubble triggered crisis involved monetary easing, while market became uncertain about the valuation of CEE currencies. Despite the interbank market and yield curve relatedness of the ECB reactions, they were able to calm down the currency market as well. Contrary to the euro-crisis, sub-prime crisis left the former intensive common movement of CEE currencies unaffected.

5. Conclusion

Currency markets are relatively close to efficient in comparison with stock or bond markets as Kiss and Kosztopulosz (2013) suggests. CEE currencies suffered from increased fat tailness under CHF denomination – as a result of permanent crises since 2007. Monetary easing by the ECB reduced the occurrence of fat-tailed returns, but the former strong common movement among CEE currencies had weakened as never since the millennia. Capital markets have complex network structure, where crisis times are features instead of bugs. Prices are able to differ from their expected value easily and structural failures (bank defaults like the LTCM in 1998 or Lehman Brothers in 2008) triggering even fatter tailed returns. The lesson of the current crisis for CEE currencies that their relationship was altered less by network dynamics under sub-prime crisis, while sovereign crisis was able to erase even a decade old convergence. These fundamental changes affected the banking sector badly – FCYLs had lower quality even before 2008 (Gyöngyösi, 2010), but there was a space for further decrease under euro-crisis.

Central banks are responsible for financial stability by law and recent changes suggesting the necessity it's more sophisticated appearance as a secondary objective for monetary policy. Despite the triviality of this need, it would be hard to operationalize. Indeed, recent steps as banking union (Darvas, 2013) or delegation supervisory powers to central banks (MNB, 2013) seem to be addressing this problem.

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