Conventional and Unconventional Balance Sheet Practices and its Impact on Currency Stability

Gábor Dávid Kiss
University of Szeged
Faculty of Economics and Business Administration, Division of Finance
Kálvária sgt. 1
Szeged, 6722
Hungary
e-mail: kiss.gabor.david@eco.u-szeged.hu

Abstract
The impact of balance sheet expansions on extreme currency fluctuations was tested in present paper on a sample with seven European central banks between 2006 and 2014. Balance sheets can evolve due to conventional and unconventional monetary practices – mostly by foreign exchange reserve policies or by quantitative easing. Qualitative easing can undermine money quality as recent literature suggested. Current paper summarized the structural changes in the balance sheets and in the variety of instruments to capture and test some indicators to evaluate later hypothesis. Extreme currency fluctuations were captured trough the contravention of normal distribution at tails. Balance sheet developments and the appearance of extreme currency fluctuations were the product of crisis processes but they were in a poor functional relationship with each other – rejecting the money quality-asset quality hypothesis on medium run.

Keywords: central bank balance sheet, monetary expansion, extreme currency fluctuation
JEL codes: C32, F31, F35, G15, E44

1. Introduction

Current paper focuses on the issue of casual relationships among central bank balance sheet expansions and currency stability, following the thoughts of Bagus and Howden (2009). In their work they raise the following idea of "the quality of money depends on central bank balance sheet" in the light of quantitative and qualitative monetary easing. Furthermore they connect this aspect with central bank credibility as well, suggesting that the "quality of a central bank's reserve assets represent the credibility of communicated policies [of price stability]" (Bagus and Howden, 2009).

The supposed unconventional monetary policy driven money quality decrease should have an impact both on inflation and foreign exchange rate devaluation. Since the European Economic Area (EEA) is still in a close to deflation state, current paper evaluates currency developments. Supposing that the European Central Bank affects the risk premia of all other EEA member central banks (due to their relatively small and open economies which limits the degree of their monetary autonomy), accommodative decisions should raise further uncertainties in currency pricing. The main added value of this paper is to evaluate, how unconventional balance sheet policies are connected to the occurrences of extreme currency fluctuations.

After seven years from the first steps towards the elaboration of subprime crisis it is time now to evaluate the upper statements: were instability of currency pricing even related to unconventional monetary expansion? The objective of current paper is to prove, that balance sheet practices are not accelerating the occurrence of extreme currency fluctuations on medium run. A currency will depreciate regardless to unconventional monetary policies if price level and growth are decreasing.

The paper is structured as follows: next section of paper summarizes theoretical background of balance sheet expansion and presents recent developments in monetary policy according to central bank balance sheets, press releases and annual reports. Third section summarizes data and the methodological background of extreme returns, and the fourth section contains the results and discussions.

2. Comparison between Theory and Practice of Monetary Policy

This section summarizes recent literature about central bank balance sheets and points on the scarcity of models to capture balance sheet and currency fluctuation interactions. To test the hypothesis of balance sheet change indicated extreme currency fluctuations, two set of variables were collected: one refers to the ratios of significant balance sheet categories while another focuses on the changes in monetary instruments.

2.1 Theoretical Background of Balance Sheet Expansion and Currency Stability

Ultimate objective of monetary policy instruments is to influence indirectly target agents activity in a market economy through central bank money. Menkhoff (1997) divides these operations to the following components: balance of payments (foreign exchange operations or capital control, decisions about minimum reserve), open market (security purchases), refinancing (covered lending) or fiscal (government security operations).

Central bank assets are interest-bearing instruments, supported by liabilities so monetary authority operates like a private market intermediary with large numbers of counterparties who are subject of reserve requirements and fulfill collateral eligibility criteria (Champ et al., 2011; Issing et al., 2001). Choice of counterparties determines crisis management[1] as well: a bank lending based economy calls for reactivation after sudden stop in funding liquidity, while counterparties can be by-passed in a capital market-based environment to maintain external financing (Lenza et al., 2010). Central bank asset quality related to the upper ways of market management via collateral policy or open market operations, with an impact on the quality of liabilities (especially money) from accounting perspective (Bagus and Howden, 2009; Caruana, 2012).

Balance sheet expansion can have many reasons. Foreign reserves can be increased alone via discrete programs of accumulation (for example to meet Guidotti-Greenspan rule or due to foreign exchange anchor-driven currency intervention) or devaluation of national currency. Quantitative easing is a broader expansion of central bank balance sheet and monetary base without altered composition of conventional assets (Lenza et al., 2010), so the expansion is not reduced on reserves only. Non-standard measures like these are used when interest rate hits zero, so the traditional instrument of central bank losts much of its stimulating power (Farmer, 2013; Bagus and Schiml, 2009), because environment can no longer be captured solely by the level of a very short-term interest rate (Lenza et al., 2010). Central bank balance sheet expansion under quantitative easing helps to reduce the risk premiums[2] of high quality assets through their increased prices (Shirai, 2014). This behavior meets BIS (2011) requirements to maintain financing liquidity[3] under turbulent times – even in a different currency! Qualitative easing happens when central bank balance sheet size remains untouched, while composition of asset holdings changed to introduce unconventional and lower quality assets in order to stabilize market or to bail out an insolvent and illiquid banking system (Lenza et al., 2010; Bagus and Schiml, 2009). The intent of measures can be different: it can focus on the re-establishment and enhancement of transmission channels like money market spreads and risk premiums at longer maturities, or it can exploit neglected transmission channels, like corporate papers and bonds, ETFs, Real Estate Investment Trust papers as it happened in Japan (Lenza et al., 2010; Shirai, 2014; Bagus and Schiml, 2009). Financial stability can be supported via liquidity provision to funding in domestic and foreign currencies, while macroeconomic stability can be maintained through bond purchases, large-scale foreign exchange interventions and credit provisions to the private sector as Stone et al. (2011) suggested.

[1] Eurozone financial activity based on commercial banks with almost 2000 clients for the ECB which requires more attention on market making. US economy is focused more on capital markets with a small number (twenty) of primary dealers of the FED, resulted some programs to support trade of asset based commercial papers and money market investments (Bagus and Schiml, 2009).

[2] Risk premium management can be even more complicated for the ECB, where long-term interest rates fluctuate in response to the fiscal conditions of the member states (Hamori and Hamori, 2010). Ellison and Tischbirek (2014) distinguishes among short- and long-term interest rates: first should respond to inflation while second should respond to output by selling short-term treasuries and re-investing the proceeds in long-term treasuries.

[3] Funding liquidity: to raise cash either via the sale of an asset or by borrowing (BIS, 2011)

Foreign exchange rate and monetary policy have many interactions even if floating arrangement is applied: Vargas-Silva (2010) mentions two mainstream methods: the purchasing power parity method which exploits price level differences among countries and the monetary approach of exchange rates which involves m_t domestic (m_t* foreign) money supply, y_t domestic logarithmic income (y_t* foreign) and r_t domestic interest rate (r_t* foreign) differences to explain s_t spot currency rates with α and β weights (1):

$$s_t = (m_t - m_t^*) - \alpha(y_t - y_t^*) + \beta(r_t - r_t^*). \quad (1)$$

Madura (2008) involves even more variables into his model of indirect intervention, where changes in s_t spot currency rates depends on the changes in the following variables: differential between domestic π_t and the foreign π_t* inflations, the differential between r_t domestic and the r_t^* foreign interest rates, the differential between the domestic and the foreign income levels, change in government controls g_t, and change in expectations of future exchange rates F_t (2):

$$\Delta s_t = f(\Delta(\pi_t - \pi_t^*), \Delta(r_t - r_t^*), \Delta(y_t - y_t^*), \Delta(g_t - g_t^*), \Delta(F_t - F_t^*)). \quad (2)$$

Assuming that one country has been affected by asymmetric shocks, the following (3) equations can be defined:

$$\pi_t = \pi_t^* + l \; and \; y_t = y_t^* + k \quad (3)$$

Where $l < 0$ is a sign of decreasing price level and $k < 0$ represents weaker economic growth. Because the paper focuses on the EEA where a free movement of capital is, let's assume that $\Delta(g_t - g_t^*) = 0$. Future exchange rates can be represented[4] by differences in re_t interest rate expectations: $\Delta(F_t - F_t^*) = \Delta(re_t - re_t^*)s_t$. Interest rates can be defined by (4) Taylor rule as the function of inflation and economic growth, assuming that both central bank has the same preferences about their coefficients ($\alpha \; and \; \beta$), as well as the πt_t targeted inflation and the yp_t potential economic growth is similar:

$$\begin{aligned} r_t &= \alpha(\pi_t - \pi t_t) + \beta(y_t - yp_t), \\ r_t^* &= \alpha(\pi_t^* - \pi t_t) + \beta(y_t^* - yp_t), \end{aligned} \quad (4)$$

So the interest rate differential will be the following, after utilizing equation (3):

$$r_t - r_t^* = \alpha l + \beta k, \quad (5)$$

as well as for interest rate expectations:

$$re_t - re_t^* = \alpha le + \beta ke. \quad (6)$$

Utilizing equations (3-6), the changes in s_t spot currency rates can be rewritten as follows:

$$\Delta s_t = f(\Delta(l), \Delta(\alpha l + \beta k), \Delta(k), \Delta(\alpha le + \beta ke)). \quad (7)$$

Now it is possible to define, what is happening with the currency under different scenarios (assuming that variables of function (7) are in a linear relationship):
Scenario I. under an asymmetric demand shock in the Eurozone (8) with decreasing price levels ($l<0$) and growth ($k<0$), Euro shall depreciate with an appreciation of other EEA currencies:

$$\Delta s_t < 0 = f(\Delta(l < 0), \Delta(\alpha l < 0 + \beta k < 0), \Delta(k < 0), \Delta(\alpha le < 0 + \beta ke < 0)). \quad (8)$$

[4] $\Delta(F_t - F_t^*) = \Delta((1 + re_t)s - (1 + re_t^*)s) = \Delta(re_t - re_t^*)s$

Scenario II. when cross-country inflation and growth coefficients are flattened out by crisis spillover-effects (9), currency rates became stabilized:

$$0 = f(0,0,0,\Delta(\alpha le \approx 0 + \beta ke \approx 0)). \quad (9)$$

Scenario III. the exit from crisis creates positive price level (*l>0*) and growth (*k>0*) coefficients in the Euro-area, because other EEA country fundamentals are lagged behind – with an appreciating Euro as a result:

$$\Delta s_t > 0 = f(\Delta(l > 0), \Delta(\alpha l > 0 + \beta k > 0), \Delta(k > 0), \Delta(\alpha le > 0 + \beta ke > 0)). \quad (10)$$

Unfortunately, Scenario III can happen, when an another key currency regenerates earlier from a global financial crisis, at it is happened with the US economy in 2015 – despite the stagnation in the price levels due to the dramatic fall of oil prices. Equation (10) means the depreciation of euro against US dollar, causing some turbulences for other EEA currencies as well, even if they are in equation (9) condition.

The main lesson of Scenario I and III is that currency turbulences are happening at the beginning and at the exit of crisis-related monetary policy, but not when the accommodative steps are done! Without any unconventional practices. Therefore it could be argued that central banks consider the fluctuations instead of targeting them, since exchange rate affects expected inflation and output path (Aleem and Lahiani, 2014; Papadamou et al., 2015).

Recent literature about currency market focused mostly on the interactions among currencies instead of focusing on the impacts of unconventional balance sheet policies: Gray (2014) pointed on the intensified co-movements since August 2007, while Tamakoshi and Hamori (2014) presented asymmetric responses in correlations with higher dependency during periods of joint appreciation of US dollar (USD), euro (EUR), British pound (GBP), and Swiss franc (CHF). Stelios (2014) had similar results for emerging markets, where BRICs have become more internationally integrated after the US financial crisis. Asymmetric behavior was in crosshairs of Dimitriou and Kenourgios (2013) with the decrease of exchange rates correlations during the turmoil periods. Chatratha et al. (2014) focused much more on the impact of news with the analysis of US high frequency data of co-jump statistics. Central East European currencies responded to central bank verbal interventions only during the crisis period as Égert and Kočenda (2014) suggested, following their research on macro data (CPI, PPI, GDP, CA etc.). Interest and exchange rate interactions at ECB were analyzed by Demir (2014) without deeper analysis of the monetary instruments.

But the question of unconventional balance sheet-currency stability interaction remained unanswered. Current paper uses six *R* ratios to capture balance sheet developments (BS_m): R_{ed} equity-to-debt ratio, R_{tr} transparency ratio, R_{de} defense ratio are representing risk-avareness (Farmer, 2013; Lenza et al., 2010; Bagus and Howden, 2009), while R_L lending-to-asset, R_S securities-to-asset and R_E asset expansion (total assets to their initial levels in January 2006) ratios are representing easing preferences. Equity-to-debt ratio (leverage) measures how central bank's capital is able to cushion losses when rising interest rates leads to falling bond prices and early repayments in order to avoid negative equity and monetization of these losses. Low transparency (increased share of "other" assets and securities) increases concerns about that the currency is backed by low quality (illiquid) assets, therefore their overall weight in the balance sheet have to be measured. Defense ratio captures the share of foreign reserves from total assets, representing the central bank's commitment to meet the credit rating requirements and its ability to meet partner banks foreign liquidity demand (Antal and Gereben, 2011). Lending-to-asset and securities-to-asset ratios depend on central bank preferences about funding liquidity management. Later ratios shall increase with close to constant asset expansion level under qualitative easing, while quantitative or quantitative and qualitative easing allows three of them to increase.

The main added value of this paper is that balance sheet practices are unrelated to extreme currency fluctuations, because they are happening in different time. This null hypothesis was tested via two Vector Autoregression models with *i=1* lags of sole *m* monthly number of extreme fluctuations NoX_m as null hypothesis and monthly number of extreme fluctuations enhanced with additional balance sheet BS_m information as alternative hypothesis (11):

$$NoX_m = \sum_{m*t-30}^{m*t} \Delta s_{t,extreme},$$
$$H0: NoX_m = f(NoX_{m-i}), H1: NoX_m = f(NoX_{m-i}, BS_{m-i}). \quad (11)$$

The next subsection summarizes the changes in balance sheets of sample central banks to identify changes in ratios and to give a more detailed list of monetary policy instruments.

2.2 Balance Sheet Expansion in Practice

Currency rates should react on the changes in central bank asset quality according to the literature. This subsection summarizes recent changes from the last 8 years, presenting a brief view about joint actions to provide FX liquidity to each other, followed by a chronological description of policy changes to manage funding liquidity at higher maturities. On a market, which is characterized by continent-wide parent-subsidiary commercial bank networks (Árvai et al., 2009; Heryán and Stavárek, 2012). These reactions were collected from central bank press releases and annual reports between 2006 and 2014.

Central bank balance sheet ratios were studied in three intervals: before the crisis prior the first reciprocal swap agreement (swap line) among the Bank of Canada, the Bank of England, the European Central Bank, and the Swiss National Bank, the Bank of Japan and the Federal Reserve on December 3. 2007 (Table 1). This agreement was followed by the numerous accommodative monetary decisions until the June 2011, when the ECB stated to react on the emerging sovereign crisis in the Eurozone. Current paper analyzes seven different central banks with own currency, one group showed some signs of quantitative or qualitative easing (European Central Bank[5], Swiss and Sweden National Banks), while the other group had a foreign asset-focused balance sheet (Danish, Czech, Hungarian, and Polish National Banks) as defense-ratio suggests. Other assets were marginal – except the ECB, where they went above 10% after 2007 and reached 18% after 2011, reflecting on marketable asset holdings without monetary policy purposes (i.e. securities denominated in euro which are held outright for investment purposes at its own risk). Lending activity became visible on monthly basis only at the ECB during the entire time set, while Danish national bank was active lender in the first two periods, as well as the Swedish national bank was active under subprime-crisis interval. The dominance of FX reserves can bias this ratio, but Czech and Polish lending activity was completely erased by time however it increased in Hungary in the third phase. The stimulation of security markets emerged even more in the second half of the crisis at the ECB, while it was constant for Denmark and Hungary and became negligible for Swiss national bank. Leverage ratio reflects on the shock-absorbing capability of the central bank. Well, it is negative for Czech and positive but close-to-zero at the ECB, Hungarian and Polish central banks, while Swiss, Swedish and Danish national banks are remarkably robust.

[5] Bagus and Howden (2009), Farmer (2013) defines the period of December 2008-March 2009 for quantitative easing, while Chen et al. (2012) added Eurosystem's Covered Bond Purchase Programme to the list between May 2009 and June 2010 as well.

Table 1: Central bank balance sheet ratio averages (monthly data)

	defense	leverage	transparency	lending	securities	expansion
	January 2006 - November 2007 (pre-crisis)					
ECB	13%	6%	1%	38%	8%	96%
Swiss	43%	127%	1%	0%	5%	59%
Sweden	85%	39%	2%	2%	0%	16%
Czech	95%	-13%	1%	2%	0%	5%
Denmark	52%	17%	1%	37%	10%	45%
Hungary	92%	4%	2%	2%	3%	8%
Poland	96%	2%	1%	2%	0%	5%
	December 2007 - May 2011 (subprime-crisis)					
ECB	10%	4%	11%	35%	16%	156%
Swiss	49%	50%	0%	0%	2%	98%
Sweden	61%	21%	1%	22%	0%	118%
Czech	97%	-17%	1%	1%	0%	3%
Denmark	64%	13%	1%	24%	6%	48%
Hungary	94%	4%	2%	1%	3%	11%
Poland	95%	4%	2%	3%	0%	8%
	June 2011 - October 2014 (sovereign or Euro-crisis)					
ECB	10%	4%	18%	32%	24%	221%
Swiss	84%	14%	0%	0%	1%	65%
Sweden	87%	19%	1%	0%	1%	25%
Czech	98%	-9%	0%	0%	0%	2%
Denmark	88%	14%	0%	4%	6%	17%
Hungary	94%	6%	1%	3%	2%	15%
Poland	99%	4%	0%	0%	0%	2%

Source: ECB, Swiss, Sweden, Czech, Hungarian, Polish and Danish National Banks

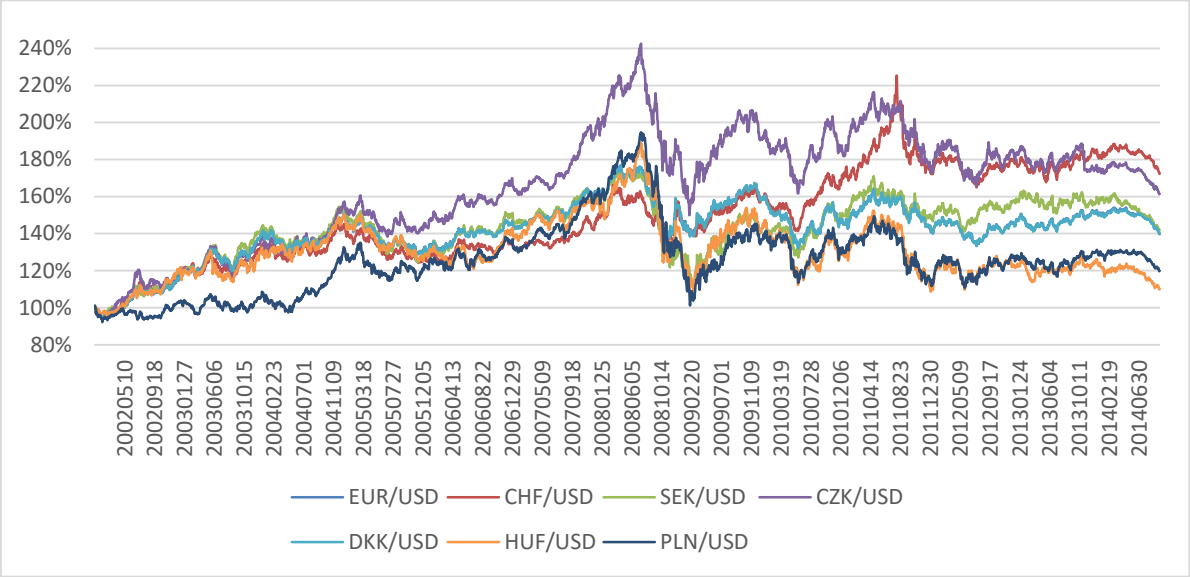
Current paper focuses how central bank asset quality is related to the quality of money – represented by pricing uncertainties. This subsection summarized the findings about two group of central banks, one which applied some sort of quantitative easing while another mostly had a FX reserve focus.

3. Data and Methodology

Data for two groups of central banks is obtained between January 2006 and October 2014: the first group followed some quantitative and qualitative easing in the sample period (European Central Bank, Swiss and Sweden National Banks), while the other group had a foreign asset-focused balance sheet (Danish, Czech, Hungarian, and Polish National Banks). Daily closing currency data from Bloomberg database were analyzed between January 1 2002 and October 1 2014 to involve some pre-crisis period for control.

Daily closing data of Euro (EUR), Swiss Franc (CHF), Swedish Koruna (SEK), Czech Koruna (CZK), Danish Koruna (DKK), Hungarian Forint (HUF) and Polish Zloty (PLN) was tested with US Dollar (USD) denomination between January 1 2002 and October 1 2014. Sample currencies appreciated until the first half of 2008 after a minor correction in 2005. The interval between 2008 and 2013 was about a cycle of devaluation and appreciation, presenting market pricing uncertainty (Figure 1).

Figure 1: Developments of Selected European Currencies between 2002 and 2014 (January 1 2000=100%)



Source: Bloomberg

Logarithmic first differentials of sample currencies were stationary but mostly asymmetric (except CZK/USD and DKK/USD) and suffered from high excess kurtosis (Table 2). Extreme changes in currency pricing is more common than is should be under the assumption of normal distribution – normal distribution was clearly rejected for entire data set. Autocorrelation or heteroscedasticity did not characterized the data.

Table 2: Descriptive Statistics of Currency Log Differentials

currency	mean	standard deviation	skewness	kurtosis	normal distribution Jarque-Bera test (p)	autocorrelation Ljung-Box test (p)	conditional heteroscedasticity ARCH-LM test (p)	unit root ADF test (p)
EUR/USD	0.0001	0.0060	0.1279	5.3376	0.0000	0.8582	0.8752	0.0000
CHF/USD	0.0002	0.0068	-0.5118	14.7053	0.0000	0.2655	0.3442	0.0000
SEK/USD	0.0001	0.0078	0.2506	6.7777	0.0000	0.2328	0.4135	0.0000
CZK/USD	0.0001	0.0080	0.0033	6.8158	0.0000	0.3471	0.5302	0.0000
DKK/USD	0.0001	0.0062	0.0165	4.6254	0.0000	0.5958	0.7195	0.0000
HUF/USD	0.0000	0.0099	-0.3468	6.4052	0.0000	0.9039	0.9442	0.0000
PLN/USD	0.0001	0.0092	-0.1089	6.7951	0.0000	0.3415	0.6148	0.0000

Source: author´s calculation, using Kevin Sheppard's MFE toolbox for Matlab

Sample currencies followed floating exchange rate policy or fluctuated within a ±15% broad band (like Denmark as ERMII member and Hungary between 2001 and 2008) while upper limits were introduce to stop excess appreciation of Swiss Franc in 2011 or to fight deflation of Czech Koruna in 2013 (IMF, 2013). Except these cases, central banks did not intervene directly to manage exchange rates – the list of indirect instruments reduced to manage interest rate premiums, central bank balance sheet activity, EU fund transformations and FX swap and repo agreements. This paper uses various indicators to capture asset quality and described main changes in latest monetary policy to evaluate currency pricing behaviors at the same time.

Temporary failures of efficient market theory could be used as a good approximation to capture extreme currency fluctuations. Fama (1970) points on the problem of favorable distribution of returns – despite the theoretical elegance of normal distribution, empirical data follows some kind of fat tailed distribution (page 399). Current paper applies this idea to choose an adequate method to capture extreme changes in currency rates – as a sign of market uncertainty about money quality. Under the assumption of market efficiency can be a temporary phenomenon, a set of $\mathbb{R}$ market returns can be separated on two groups of $\mathbb{N}$ normal (r_n) and $\mathbb{X}$ extreme returns (12)

$$\mathbb{R} = \mathbb{N} \cup \mathbb{X} \tag{12}$$

Therefore "normality" can be defined as a lack of extreme returns, statistical characteristics of N subset have to converge to the idealistic N~(0,1,0,3) case, where standardized returns have zero expected value, 1 standard deviation, showing symmetry (skewness=0) and extreme fluctuations are dying out fast due to exponent tails (kurtosis=3). To capture extreme values of a data set, statistical and distance based methods are suggested by Jiawei and Micheline (2004). Statistical approach focuses on an expected theoretical distribution of the sample, while distance based methods applying the dendrogram from hierarchical cluster analysis to capture underpopulated clusters with outlier data.

Fat tailed returns ($r_{\mathbb{X}fat}$) computed by the difference on the tails between theoretical normal and empirical distribution utilizing its "S"-shaped from, described by Clauset et al. (2007) and Gabaix et al. (2003) to see the difference between theoretical and empirical returns under p_L low probability (13).

$$r_{\mathbb{X}fat+,p_L} \gg r_{normal,p_L} \text{ or } r_{\mathbb{X}fat-,p_L} \ll r_{normal,p_L} \text{where } p_L \ll p_{E(r)} \quad (13)$$

Conditional volatility (σ_t) can increase under turbulent times of pricing uncertainties, what can be measured with a GARCH(1,1) model (14) on monthly currency data:

$$r_t = \sigma_t * \varepsilon_t \text{ and } \sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \quad (14)$$

where ε_t is the normal distributed error-term and $\alpha + \beta < 1$ (Bollerslev, 1986).

Vector Autoregression (VAR) captures the dynamic interactions for a set of *K* time series variables $y_t = (y_{1t}, \dots, y_{Kt})'$. The basic model of order *p* VAR has the form of (15) (Lütkepohl and Kratzig, 2004).

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \quad (15)$$

Where the A_i's are *(KxK)* coefficient matrices and $u_t = (u_{1t}, \dots, u_{Kt})'$ is an unobservable error term – assumed to be a zero-mean independent white noise process with time-invariant, positive definite covariance matrix: $u_t \sim (0, E(u_t, u_t'))$.

Present paper studied three setup of first order VAR models. First the number of extreme returns and monthly conditional variances will be regressed to themselves to see the significance of previous data in the model (16, 17):

$$\Delta No\ of\ X\ returns_t = constant + A_1 \Delta No\ of\ X\ returns_{t-1} + u_t \quad (16)$$
$$\Delta\sigma_t = constant + A_1 \Delta\sigma_{t-1} + u_t \quad . \quad (17)$$

Second, balance sheet ratios (R) are involved as well to check their significance and the increase in coefficient of determination (r^2) (18,19):

$$\Delta No\ of\ X\ returns_t = constant + A_1 \Delta[No\ of\ X\ returns_{t-1}, R_{t-1}] + u_t. \quad (18)$$
$$\Delta\sigma_t = constant + A_1 \Delta[\sigma_{t-1}, R_{t-1}] + u_t \quad . \quad (19)$$

4. Discussion on Empirical Results

To evaluate the idea of calmed currency pricing under high central bank asset quality, current paper tests the patterns of extreme return appearance in time. When asset quality is high, extreme returns should occur less often when the quality decreases. This section summarizes some basic statistics of currencies and their volatility and extreme returns, then characterizes their properties under difference monetary environment described in upper sections.

4.1 Extreme Currency Fluctuation

Compared to the original descriptive statistics, fat tailed method provided a subset of normal returns (table 3). First moment (mean) remained around zero, while second moment (standard deviation) decreased due to data reduction. This method is insensitive to third moment, a convergence to zero

(symmetry) depends on luck. Fat tailness was reduced, kurtosis is near 3. The amount of extreme returns remained moderated, their overall weight remained under 8% of the sample.

Table 3: Extreme Returns by Fat Tailed Method

	EUR	CHF	SEK	CZK	DKK	HUF	PLN
mean r(n)	0.0005	0.0001	0.0003	0.0004	0.0005	0.0006	0.0006
standard deviation r(n)	0.0045	0.0054	0.0059	0.0059	0.0048	0.0080	0.0068
skewness r(n)	0.1495	0.0017	0.0317	0.0821	0.1291	0.0579	0.0443
kurtosis r(n)	2.5980	2.6940	2.5670	2.7479	2.4595	2.5062	2.7277
X+ threshold	0.0119	0.0130	0.0153	0.0156	0.0121	0.0204	0.0188
X- threshold	-0.0092	-0.0133	-0.0135	-0.0137	-0.0096	-0.0171	-0.0154
No X+	86	102	85	90	87	65	71
No X-	201	77	134	137	189	135	152
No Normal	3320	3321	3320	3320	3320	3320	3320
elapsed time (sec)	0.09						

Source: author´s calculation

The objective of current paper is to capture the effects of balance sheet expansion on extreme currency fluctuation. Table 4 compares pre- and post-balance sheet expansion phases from the aspect of fat tailed returns. Expansive phases can be characterized by significant increase in extreme fluctuation with a focus on subprime crisis. This test supports the initial hypothesis of functional relationship between asset quality and money quality but proves only that the two phenomena happened in the same time in the case of ECB, SNB, SR, MNB.

Table 4: Extreme Returns Before and After Monetary Expansion (Fat Tailed Method)

central bank	t-test H	inflexion point	start of previous period	inflexion date	end of next period	share of extreme days	
						before	after
ECB	1	2	20060303	20070903	20090303	1%	16%
	1	4	20090303	20110902	20130201	12%	9%
SNB	1	2	20061003	20080303	20090501	1%	20%
SR	1	2	20061103	20071203	20090903	0%	17%
	1	5	20110103	20120601	20130703	12%	6%
CNB	1	3	20090803	20101001	20141001	8%	7%
DNB	1	1	20020101	20060901	20070903	5%	0%
MNB	1	1	20020101	20070202	20090403	5%	11%
PNB	0	1	20020101	20060703	20091002	6%	10%

Notes: * H=1 signs significant difference between extreme return set of previous period and current one (t-test, p=0.05), highlighted periods contained subprime crisis

Source: author´s calculation

4.2 Conditional Volatility

GARCH (1,1) model fitting aimed the extraction of conditional variances to cross-check our results about monthly number of extreme fluctuations. Previous month's volatility had a significant impact on present month's volatility in most of the cases with higher coefficient than 0.66, while innovations were less important (table 5).

Table 5: GARCH (1,1) Coefficients – Monthly Data (2006-2014)

	EUR/USD	CHF/USD	SEK/USD	CZK/USD	DKK/USD	HUF/USD	PLN/USD
ω	0.00	0.00	0.00	0.00	0.00	0.00*	0.00
α	0.12*	0.21	0.18	0.10	0.18	0.18	0.11
β	0.82**	0.74**	0.60	0.86**	0.78**	0.66**	0.82**

Notes: ** sign. at p<0.05; * sign. at p<0.10

Source: author´s calculation, UCSD toolbox

4.3 Vector Autoregression to Test Extreme Currency Fluctuation and Balance-Sheet Interactions

Monthly number of extreme currency fluctuations are negatively related with each other in time, indicating that these glitches in pricing are a really short run phenomena (Table 6). Balance sheet developments had a calming impact on currency fluctuations mostly, changes in different ratios or in its

overall size decreased the number of extreme changes. Swiss National Bank is one exception, where reserve accumulation was driven by a dramatic Franc appreciation with a temporary intervention zone as a result. Hungarian, Polish and Czech national banks followed a conservative monetary policy, where majority of assets were categorized as foreign exchange reserves. Therefore their balance sheet sizes were influenced mostly by currency fluctuations. Central banks of Sweden and Denmark were active in their lending activity only during the first phase of the crisis (2008-2010), later they followed a CEE-like strategy, but suffered from appreciation like Switzerland or Czech Republic. ECB's security purchase programs had a smoothing impact on Euro exchange rate pricing, while balance sheet expansion was significant. Determination coefficient (R^2) has been increased due to the additional balance sheet data.

Table 6: Vector Autoregression – Monthly Number of Extreme Currency Fluctuations (1 lag)

entire	EUR/USD	CHF/USD	SEK/USD	CZK/USD	DKK/USD	HUF/USD	PLN/USD
r^2	0.22	0.19	0.16	0.03	0.11	0.04	0.03
monthly number of extreme fluctuation (t-1)	-0.46	-0.44	-0.39	-0.16	-0.34	-0.19	-0.18
constant	0	0	0	0	0	0	0
entire	EUR/USD	CHF/USD	SEK/USD	CZK/USD	DKK/USD	HUF/USD	PLN/USD
R^2	0.38	0.24	0.24	0.06	0.14	0.07	0.12
monthly number of extreme fluctuation (t-1)	-0.43	0	-0.41	-0.13	0	-0.16	0
Reserves/Assets	-108.29	6.14	0	0	0	0	0
Equity/Assets	0	0	0	0	0	1.27	-12.49
Other/Assets	0	0	-111.99	0	0	0	0
Lending/Assets	0	-687.99	0	0	0	0	0
Securities/Assets	-97.91	0	0	0	0	0	0
Assets expansion	-10.04	0	0	0	-3.51	0	0
constant	0	0	0	0	0	0	-0.01

Notes: nonzero beta coefficients are significant at p<0.10

Source: author´s calculation, JPL toolbox

Change of monthly conditional volatility mostly depended from its value with a "calming" effect: volatile months were followed by smoother ones (Table 7). Introduction of balance sheet ratios increased determination in every cases. Accommodative lending and security market policies of ECB verified upper result of its calming impact, while the decrease in transparency accelerated pricing uncertainties for euro, Swiss franc, and Czech koruna. Despite that Czech National Bank was the most conservative in the sample, it's lending and reserving activities indicated some sort of volatility. The reason can be found in their strong fundamentals: when even the CNB has to be accommodative, there are serious troubles on the market.

Table 7: Vector Autoregression – Monthly Conditional Variances (1 lag)

entire	EUR/USD	CHF/USD	SEK/USD	CZK/USD	DKK/USD	HUF/USD	PLN/USD
r^2	0.02	0.00	0.04	0.07	0.04	0.09	0.04
conditional volatility (t-1)	0.00	0	-0.19	-0.27	-0.20	-0.29	-0.20
constant	0	0	0	0	0	0	0
	EUR/USD	CHF/USD	SEK/USD	CZK/USD	DKK/USD	HUF/USD	PLN/USD
R^2	0.16	0.21	0.33	0.19	0.25	0.12	0.08
conditional volatility (t-1)	0	-0.06	0	-0.24	-0.42	0	0
Reserves/Assets	-0.01	0.00	0	0.12	0	0	0
Equity/Assets	0	0	0	0	0	0	0.00
Other/Assets	0.00	0.03	-0.07	0.13	0	0	0
Lending/Assets	-0.01	0	0	0.13	0	0	0
Securities/Assets	-0.01	0	0	0	0	0	0
Assets expansion	0	0	0	0	0	0	0
constant	0	0	0	0	0	0	0.00

Notes: nonzero beta coefficients are significant at p<0.10

Source: author´s calculation, JPL toolbox

Both of methods had the same result: currency turbulences are not related to or even calmed by unconventional decisions.

5. Conclusion

Current paper analyzed balance sheet activity impact on currency stability at seven European central banks between 2006 and 2014. Currency stability was measured trough temporal patterns of extreme currency fluctuations and conditional volatility, while balance sheet developments were studied with six different ratios representing monetary activism. Overall balance sheet expansions had calming or no impact on extreme currency fluctuations on medium run, supporting the theoretical assumptions of Scenario I and III related turbulences. The asset quality-money quality hypothesis was unsupported on the selected interval, currency pricing distortions happened far beyond the reaction horizon of balance sheet practices. Empirical results are suggesting that expectations about future monetary policy – and therefore currency path – were stabilized by these accommodative steps.

These results would be different in a non-deflationary environment, where price stability objective means more than avoiding deflation. Current circumstances require (or at least tolerate) monetary easing, but lending or outright activities were remarkable only at the ECB. Other central bank balance sheets were expanding due to foreign exchange reserve accumulation or trough some temporary lending activities. Therefore currency stability concerns will be actual again when some of current accommodative policies will be abandoned.

Acknowledgement

The project was partially funded by „TÁMOP-4.2.1.D-15/1/KONV-2015-0002– „Establishing higher education service satisfying the needs of knowledge industry in the Southern Great Plain region" is supported by the European Union and co-financed by the European Social Fund.

References

ALEEM, A., LAHIANI, A. (2014). Monetary policy credibility and exchange rate pass–trough: some evidence from emerging countries. *Economic Modelling*, vol. 43, pp. 21–29.

ANTAL, J., GEREBEN, Á. (2011). Foreign Reserve Strategies for Emerging Economies – Before and After the Crisis. *MNB Bulletin*, vol. 6, no. 1, pp. 7–19.

ÁRVAI, Z.S., DRIESSEN, K., ÖTKER–ROBE, İ. (2009). *Regional Financial Interlinkages and Financial Contagion within Europe*. IMF Working Paper 2009-6. New York: International Monetary Fund.

BAGUS, P., HOWDEN, D. (2009). Qualitative Easing in Support of a Tumbling Financial System: a Look at the Eurosystem's Recent Balance Sheet Policies. *Economic Affairs*, vol. 29, no. 4, pp. 60–65.

BAGUS, P., SCHIML, M.H. (2009). New Models of Monetary Policy: Qualitative Easing by the FED. *Economic Affairs*, vol. 29, no. 2, pp. 46–49.

BOLLERSLEV, T. (1986): Generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics*, vol. 31, pp. 307–327.

BIS (2011). *Global Liquidity – Concept, Measurement and Policy Implications*. BIS CGFS Publications 2011–45. Basel: Bank of International Settlements.

CARUANA, J. (2011). *Why central bank balance sheets matter*. BIS Papers 2012-66. Basel: Bank of International Settlements.

CHAMP, B., FREEMAN, S., HASLAG, J. (2011). *Modeling Monetary Economies*, vol. 3. Cambridge: Cambridge University Press.

CHATRATHA, A., MIAOB, H., RAMCHANDERB, S., VILLUPURAM, S. (2014). Currency jumps, cojumps and the role of macro news. *Journal of International Money and Finance*, vol. 40, pp. 42–62.

CHEN, Q., FILARDO, A., HE, D., ZHU F. (2012). *International spillovers of central bank balance sheet policies.* BIS Papers 2012-66, Basel: Bank of International Settlements.

CLAUSET, A., SHALIZI, C.R., NEWMAN, M.E.J. (2009). Power–law distributions in empirical data. *SIAM Review*. vol. 51. pp. 661–703.

DEMIR, I. (2014). Monetary policy responses to the exchange rate: Empirical evidence from the ECB. *Economic Modelling*, vol. 39, pp. 63–70.
DIMITRIOU, D., KENOURGIOS D. (2013). Financial crises and dynamic linkages among international currencies. *Journal of International Financial Markets*, vol. 26, pp. 319–332.
ÉGERT, B., KOČENDA E. (2014). The impact of macro news and central bank communication on emerging European forex markets. *Economic Systems*, vol. 38, no. 1, pp. 73–88.
ELLISON, M., TISCHBIREK, A. (2014). Unconventional government debt purchases as a supplement to conventional monetary policy. *Journal of Economic Dynamics and Control*, vol. 43, pp. 199–217.
FAMA, E.F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *Journal of Finance*, vol. 25. pp. 383–417.
FARMER, R.E.A. (2013). Qualitative easing: a new tool for the stabilization of financial markets. *Bank of England Quarterly Bulletin*, vol. 53 no. 4, pp. 405–413.
GABAIX X., GOPIKRISHNAN P., PLEROU V., STANLEY, H.E. (2003). A theory of power–law distributions in financial market fluctuations. *Nature*, vol. 423. pp. 267–270.
GRAY, D. (2014). Central European foreign exchange markets: a cross–spectral analysis of the 2007 financial crisis. *European Journal of Finance*, vol. 20, no. 6, pp. 550–567.
HAMORI, S., HAMORI N. (2010). *Introduction of the Euro and the Monetary Policy of the European Central Bank*. Singapore: World Scientific.
HERYÁN, T., STAVÁREK, D. (2012). Influence of the Czech Banks on their Foreign Owners' Interest Margin. *Procedia Economics and Finance*, vol. 1, pp. 168–175.
IMF (2013). *Annual Report on Exchange Arrangements and Exchange Restrictions 2013*. New York: International Monetary Fund.
ISSING, O., GASPAR, V., ANGELON, I., TRISTANI, O. (2001). *Monetary policy in the Euro Area*. Cambridge: Cambridge University Press.
JIAWEI, H., MICHELINE, K. (2004). *Data Mining Concepts and Techniques*. Amsterdam: Elsevier.
LENZA, M., PILL, H., REICHLIN, L. (2010). Monetary policy in exceptional times. *Economic Policy*, vol. 25 no. 62, pp. 295–339.
LÜTKEPOHL, H., KRATZIG, M. (2004). *Applied Time Series Econometrics*. Cambridge: Cambridge University Press.
MADURA, J. (2008). *International Financial Management*. Mason: Thomson.
MENKHOFF, L. (1997). *Instruments for European Monetary Union*. Heidelberg: Springer.
PAPADAMOU, S., SIDIROPOULOS, M., SPYROMITROS, E. (2015). Central bank transparency and the interest rate channel: Evidence from emerging economies. *Economic Modelling*, vol. 48, pp. 167–174.
SHIRAI S. (2014). Japan's monetary policy in a challenging environment. *Eurasian Econ Rev*, vol. 4, pp. 3–24.
STELIOS D. B. (2014). Contagion, decoupling and the spillover effects of the US financial crisis: Evidence from the BRIC markets. *International Review of Financial Analysis*, vol. 33, pp. 58–69.
STONE, M., FUJITA, K., ISHI, K. (2011). *Should Unconventional Balance Sheet Policies be Added to the Central Bank Toolkit? A Review of the Experience So Far*. IMF Working Paper 2011-145. New York: International Monetary Fund.
TAMAKOSHI, G., HAMORI, S. (2014). Co–movements among major European exchange rates: A multivariate time-varying asymmetric approach. *International Review of Economics and Finance*, vol. 31, pp. 105–113.
VARGAS-SILVA, C. (2010). Exchange rates. In: FREE, R.C. (ed.): *21st Century Economics – a Reference Handbook*. London: Sage.