Monetary Instruments, FX Rates and 10Y Yields Outside the Eurozone

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Abstract
Excessive appreciation is a key problem for central banks with safe haven currencies. This study analyzes interactions between interest rate parity model and monthly balance sheet ratios among the Swiss, Sweden, and Norwegian central banks after 2009. Recent changes in lending, security accumulation and foreign claims of the Eurozone created spillover effects for safe haven currency issuers, with serious appreciation pressure and negative interest rates as a result. Fixed and random effect panel regressions were applied on monthly data to identify these developments. Security accumulation has some interaction with exchange rate movements in the sample countries, what can be utilized under future decisions to moderate herding-like appreciation.

JEL classification: C32, F31, F35
Keywords: monetary, balance sheet, safe haven

1. Introduction

The scope of current paper is to identify the main points between present accommodative monetary policy and safe haven currencies. Main problem for such issuers is the appreciation tendency causing unwanted deflation. The objective of this study is to amend central bank balance sheet ratios into the standard interest rate parity model. Safe haven currencies can be defined by their hedging benefits to the referenced asset both in normal times and in times of crisis: they are negatively correlated with equity returns but positively correlated with bond returns and market risk changes (Ranaldo & Söderlind, 2010). Central bank balance sheet activities represent their behavior to accumulate foreign exchange reserves, managing domestic liquidity through lending and security holding, or cooperating with other central banks like forming swap-lines or increase their activity through balance sheet expansion and leverage.

This study analyzes there European safe haven issuer countries (namely Sweden, Norway and Switzerland) between July 2009 and July 2016 to focus on the period when they suffered from extraordinary appreciation. Our paper has the following structure: theoretical background contains the related and amended equations of exchange rate dynamics as well as summarizes key developments of the sample central banks. The next section introduces data and summarizes the fixed and random effect panel regression methods. The study is closed with results and conclusion.

2. Theoretical Background

Interest rate parity is a traditional tool to capture the interactions between foreign exchange rates and interest rates. However can be extended to meet Taylor-rule requirements in a two-country model. This section presents how this representation can be reduced by current deflation environment and how central bank balance sheet can be amended into this model. The necessity of such inclusion is supported by the facts in the second part of the paper, summarizing the actions of sample central banks: they have a rich history of swap-lines, and at some point of the last seven years they had to become more accommodative to support their domestic banking system.

2.1 Exchange Rate Theory

Law of one price implies that changes in the exchange rate have to relate directly to differences in the inflation rates of two countries (Woodford, 2009). The log approximation of monetary policies in a two-country model (1) can be described as follows:

$$\bar{\imath}_t = \hat{\imath}_t - \phi_\pi \pi_t - \phi_y \hat{Y}_t \quad (1)$$

with components of inflation $\pi_t = log\frac{P_t}{P_{t-1}}$, output gap $\hat{Y}_t = log\frac{Y_t}{\bar{Y}_t}$, and time variation of inflation target $\hat{\imath}_t = log\frac{1+i_t}{1+\frac{I_t}{I_{t-1}}}$.

Exchange rates (2) present appreciation as a result of foreign monetary (denoted with *) policy easing or foreign output boom.

$$\Delta e_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} [E_t(\bar{\imath}_{t+j}^* - \bar{\imath}_{t+j}) + \phi_y E_t(\hat{Y}_{t+j}^* + \hat{Y}_{t+j})] \quad (2)$$

Assuming that output and inflation is similar low[1] in both countries, exchange rate is determined by interest rate premium. However, present study completes the model with another 7 central bank balance sheet ratios (BSRs) to test their ability to improve determination. The reduced form of initial equation looks as the follows:

$$\Delta e_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} [E_t(i_{t+j}^* - i_{t+j})] \quad (3)$$

with upper assumption of $\pi_t \cong 0$, $\hat{Y}_{t+j}^* = \hat{Y}_{t+j} \cong 0$. Nominal interest rates are represented by 10 year yields to focus on the longer maturities what is crucial under present qualitative easing[2] (QE) times. Quantitative easing is a broader expansion of central bank balance sheet and monetary base without altered composition of conventional assets (Lenza et al., 2010). Non-standard measures like these are used when interest rate hits zero, so the traditional instrument of central bank lost much of its stimulating power (Farmer, 2013; Bagus & Schiml, 2009), because environment can no longer be captured solely by the level of a very short-term interest rate (Lenza et al., 2010). Inclusion of BSRs in the reduced model helps to assess domestic QE practices on foreign exchange rate changes (4).

$$\Delta e_t = \sum_{j=0}^{\infty} \phi_\pi^{-(j+1)} [E_t(i_{t+j}^* - i_{t+j})] + \sum_{j=0}^{\infty} \phi_{BSR}^{-(j+1)} [BSR_{1:7,t+j}] \quad (4)$$

2.2 Central Bank Actions

The Bank of Canada, the Bank of England, the European Central Bank, and the Swiss National Bank and later the Bank of Japan have conducted a reciprocal swap agreement (swap line) with the Federal Reserve up to six month at the first time on December 3 2007 and renewed it until October 31 2013 when it was converted to a standing facility (except a short period between January and May of 2010 when agreement was abandoned due to lack of market interest). This agreement was enhanced to provide euro, Japanese yen, sterling, Swiss franc and Canadian dollar liquidity in addition to the existing operations in US dollars at the end of

[1] This assumption was supported by the zero lower bound regime that was followed by sample central banks.

[2] 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 & Schiml, 2009).

November 2010. The Norges Bank and the Sveriges Riksbank was also a member of the US swap agreement between the autumn of 2008 and the end of 2009.

There were also examples for swap agreements where euro liquidity was provided not by the ECB. Central banks of Sweden, Norway and Denmark have entered into a euro/Icelandic krona swap facility agreement with the Central Bank of Iceland (Sedlabanki Íslands) on May 16 2008. A euro swap agreement became active between Swedish and Danish and Latvian central banks after December 16 2008 and was extended with central banks of Iceland, Estonia and Latvia on May 27 2009. Later it was followed by a co-operation agreement on cross-border financial stability, crisis management and resolution between Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway and Sweden on August 17 2010.

Swiss National Bank signed CHF swap agreements multiple times: with the ECB on October 15 2008, with Polish and Hungarian national banks on November 7 2008 and January 8 2009 until January 2010. Polish National Bank reinitiated a CHF-PLN swap line later on June 25 2012.

Conventional central bank-to-International Monetary Fund (IMF) operations appeared several times as well – Sweden and Switzerland acted as a donor country due to their obligation of the Enlarged General Arrangements to Borrow (eGAB), while Norway provided financial support as a member of New Arrangements to Borrow – decided on 1995 G-7 Halifax Summit[3].

All central banks in the sample had to widen circle of accepted collaterals between August of 2007 and 2008, involving debt certificates issued by domestic banks or companies mostly at the same time when reference rates were decreased. Lending for domestic credit institutions penetrated into longer maturities on a 3-6-12 months scale, and due to scarcity of foreign currency refinancing, a parallel yield curve had to be managed in different currencies (in USD, EUR or CHF), which required joint operations (swap and repo agreements) among key central banks. This period had its peak around the summer of 2009. Lending boom died out in Sweden after January 2011, because 6M and 12M loans were phased out one year ago. Sovereign crisis in the Eurozone and a sharp appreciation in CHF signed the next turning point after September 2011 and May 2012, while foreign exchange reserves boomed both in Switzerland and Sweden. After some reaction (stopped to renew repos, sight deposits expansion, swap transactions) on its appreciating course in August, a minimum exchange rate was introduced at CHF 1.20 by Swiss National Bank from September 2011 until its abandonment on January 2015. FX reserves stabilized on high levels since then.

Corrected central bank balance sheet ratios (BSRs) were studied in three safe haven countries: Sweden, Norway and Switzerland between July 2009 and July 2016. BSRs had to be corrected by international reserves and other foreign claims to manage the never ending accumulation of foreign reserves. This paper uses seven BSRs to capture balance sheet developments. BSR_{ed} equity-to-debt ratio, BSR_{tr} transparency ratio, and BSR_{de} defence ratio represent risk awareness (Farmer, 2013; Lenza et al., 2010; Bagus & Howden, 2009), while BSR_L lending-to-asset, BSR_S securities-to-asset, BSR_{sw} swap-to-asset and BSR_E asset expansion (total assets to their initial levels on January 2006) ratios represent easing preferences. The equity-to-debt ratio (leverage) measures how the central bank's capital can cushion losses when rising interest rates lead to falling bond prices and early repayments to avoid negative equity and monetisation of these losses. Low transparency (increased share of "other" assets and securities) increases concerns about whether the currency is backed by low quality (illiquid) assets. Thus, their overall weight in the balance sheet needs to be measured. The defence ratio captures the share of foreign reserves of total assets, representing the central bank's

[3] https://www.imf.org/external/np/exr/facts/gabnab.htm

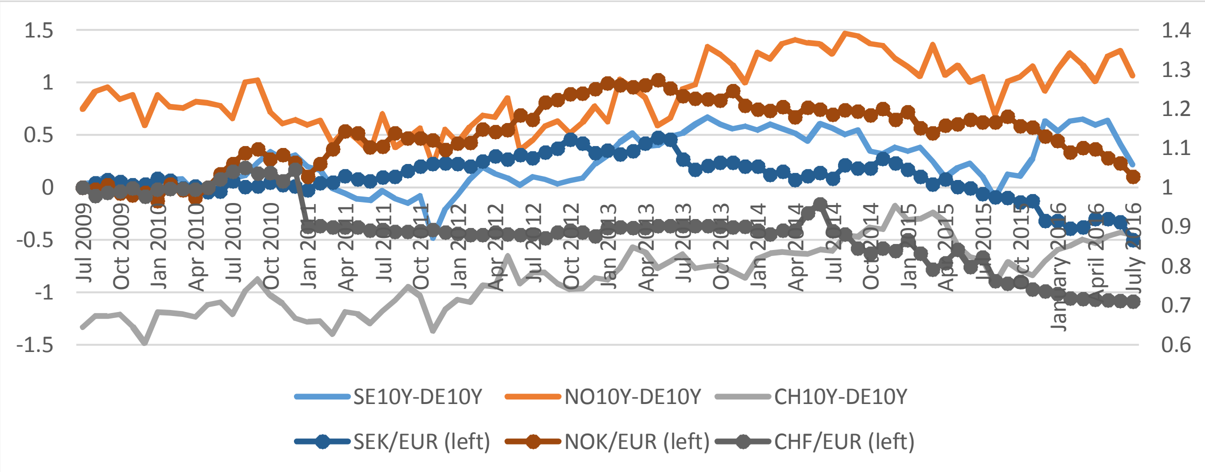
commitment to meeting the credit rating requirements and its ability to meet partner banks' foreign liquidity demands (Antal & Gereben, 2011). Lending-to-asset and securities-to-asset ratios depend on central bank preferences about funding liquidity management. Swap-to-asset rate represent the external urge to provide liquidity in domestic currency for foreign clients through other central banks.

3. Data and Methods

This section presents the dataset and the applied method of fixed and random effect panel regressions with the required diagnostics as well. Sample currencies were the subject of appreciation against the Euro after 2009, while they were not able to reduce their interest rate premium at longer (10Y) maturities (Figure 1).

Figure 1

Interest rate premium against German yields and currency development (July 2009=100)



Source: Stooq.com, central banks

Leverage ratio had serious development in Sweden and Switzerland as an indicator of the shrinkage of their corrected (non-foreign reserve related) balance sheet (Table 1). Most of their simulative power was focused on the securities market instead of traditional lending operations. Foreign exchange reserves presented a dramatic expansion their case. Norwegian central bank seemed to be relatively passive in each aspects. International swap-lines were visible in the Swiss case only.

Table 1

CBR mean levels (and standard devitions) between 2009 and 2016

		leverage	transparency	lending	securities	FX reserves	expansion	swap
Sweden	mean	6.07	0.40	0.19	0.40	34.30	0.27	0.00
	std	*6.59*	*0.39*	*0.37*	*0.39*	*32.53*	*0.37*	*0.00*
Norway	mean	0.02	0.00	0.01	0.05	0.09	1.77	0.00
	std	*0.01*	*0.00*	*0.01*	*0.03*	*0.01*	*0.63*	*0.00*
Switzerland	mean	7.29	0.12	0.00	0.48	63.84	0.18	0.13
	std	*5.17*	*0.08*	*0.00*	*0.30*	*49.80*	*0.22*	*0.25*

Source: Bloomberg, Central Bank datasets, authors' calculations

Current paper applies the Panel Data Toolbox[4] on the data, following Alvarez et al. (2015). Panel data (6) contains data matrices (with *i* columns and *t* rows) that were observed over a long period of time with *y* dependent and *X* independent variables with the following representation:

$$y_{it} = \alpha + \beta X_{it} + \mu_i + v_{it}, \text{ i=1,…, n, t=1,…, } T_i. \quad (6)$$

where μ_i represents the i-th invariant time individual effect (or unobserved component, latent variable, and unobserved heterogeneity) and $v_{it} \sim i.i.d(0, \theta_v^2)$ the disturbance (or idiosyncratic errors or idiosyncratic disturbances because these change across t as well as across i) with the following properties: $E(v_i) = 0, E(v_i v_j) = 0, E(v_i v_i^T) = \theta_v^2 I_T$ for $i \neq j$, being I_T the $T \times T$ identity matrix. In panel data models μ_i is called as ''random effect'' when it is assumed as a random variable and a ''fixed effect'' when it is treated as a parameter to be estimated for each cross section observation i. It means that fixed effect approach allows arbitrary correlation between the unobserved effect μ_i and the observed explanatory variables X_{it}. Fixed effects analysis is more robust than random effects analysis, but time-constant factors cannot be included as X_{it} – this approach is for time-varying explanatory variables[5] (Wooldridge, 2010).

The classical least squares model contains the random error as a sole random component, all other effects are assumed to be fixed constants (Rawlings et al., 1998). Fixed and random effect models were used in this paper to compare the impacts of different missing data handling methods on panel regression coefficients. Under typical fixed effect specifications, individual effects are correlated with the explanatory variables ($COV(X_{it}, \mu_i) \neq 0$), their inclusion results a biased OLS (ordinary least squares) estimation. To avoid such bias, within (it takes into account the variations in each group) estimator of the parameters (7) is computed using OLS:

$$\hat{\beta}_{fe} = (\tilde{X}^T \tilde{X})^{-1} \tilde{X}^T \tilde{y} \quad (7)$$

where "within" estimator $\tilde{y} = y - \bar{y}$ and $\tilde{X} = X - \bar{X}$ are transformed variables to represent deviations from the group means $\bar{y}$ and $\bar{X}$ (unbiased and consistent for $n \to \infty$). Statistical inference (checked by the standard *t* and *F* tests) is generally based on the asymptotic variance-covariance matrix (8):

$$VAR(\widehat{\beta_{fe}}) = \frac{(\tilde{y} - (\tilde{X}\widehat{\beta_{fe}}))^T (\tilde{y} - (\tilde{X}\widehat{\beta_{fe}}))}{(nk) - n - k} \tilde{X}^T \tilde{X}^{-1}, \quad (8)$$

where *n* denotes the elements of the panel (*countries*), *k* represents time (*years*).

The individual effects, with their standard errors and significance test can be computed as follows:

$$\hat{\mu} = \bar{y} - \bar{X}\beta, \quad (9)$$

$$VAR(\mu_i) = \frac{\tilde{\sigma}_v^2}{T_i} + \bar{X} VAR(\hat{\beta}) + \bar{X}'. \quad (10)$$

In the general panel data model (6) the loss of degrees of freedom can be avoided if the individual effects can be assumed random, where the error component $u_{it} = \mu_i + v_{it}$ includes the *i*-th invariant time individual effects μ_i and the disturbance v_{it} (μ_i is assumed independent of the v_{it} as well as they are independent of the explanatory variables: COV(X_{it}, μ_i)=0 and COV(X_{it}, v_{it})=0 for all *i* and *t*).

$$y_{it} = \alpha + X_{it}\beta + u_{it}, i = 1, \dots, n \; and \; t = 1, \dots, T_i \quad (11)$$

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[4] http://www.paneldatatoolbox.com

[5] They vary over time for some cross section units.

The random effects model (11) is an appropriate specification in the analysis of for large *n* number of individuals randomly drawn from a large population. The composed error component has the following properties:

$$E(\mu_i) = E(v_{it}) = E(\mu_i v_{it}) = 0, \tag{12}$$

$$E(\mu_i \mu_j) = \begin{cases} \sigma_\mu^2 \; i \neq j \\ 0 \; i = j \end{cases} \quad E(v_i v_j) = \begin{cases} \sigma_v^2 \; i \neq j \\ 0 \; i = j \end{cases}. \tag{13}$$

The block-diagonal covariance matrix can have serial correlation over time only between disturbances of the same individual and zero otherwise:

$$COV(u_{it} u_{js}) = \begin{cases} \sigma_\mu^2 + \sigma_v^2 \; i = j \; t = s \\ \sigma_\mu^2 \; i = j \; t \neq s \end{cases} \tag{14}$$

The GLS (generalized least squares) method yields an efficient estimator of the parameters:

$$\hat{\beta}_{re} = (X^T(\frac{1}{(T\sigma_\mu^2+\sigma_v^2)P} + \frac{1}{\sigma_v^2 Q})^{-1}X)^{-1}X^T(\frac{1}{(T\sigma_\mu^2+\sigma_v^2)P} + \frac{1}{\sigma_v^2 Q})^{-1}y = (\tilde{X}^T\tilde{X})^{-1}\tilde{X}^T y \tag{15}$$

The P and Q are the matrices that compute the group means and the differences with respect to the group means. The asymptotic variance-covariance matrix will be similar to (8):

$$VAR(\widehat{\beta_{re}}) = \frac{(\tilde{y}-(\tilde{X}\widehat{\beta_{re}}))^T(\tilde{y}-(\tilde{X}\widehat{\beta_{re}}))}{(nk)-k}\tilde{X}^T\tilde{X}^{-1}, \tag{16}$$

Several canonical tests shall be done on the panel data regression models to identify serial correlation in the error term or to select the efficient estimator between fixed and random effects models - like the Hausman test. Hausman test compares the GLS estimator of the random effects model $\widehat{\beta_{re}}$, and the within estimator in the fixed effects model $\widehat{\beta_{fe}}$, both of which are consistent under the null hypothesis (H_0: $\beta_{fe} - \beta_{re} = 0$). Under the alternative, only the GLS estimator of random effects is consistent. The computation is based on the difference between both estimators:

$$H = (\widehat{\beta_{fe}} - \widehat{\beta_{re}})' VAR(\widehat{\beta_{fe}} - \widehat{\beta_{re}})^{-1}(\widehat{\beta_{fe}} - \widehat{\beta_{re}}), \tag{17}$$

under the assumption of homoskedasticity:

$$VAR(\widehat{\beta_{fe}} - \widehat{\beta_{re}}) = VAR(\widehat{\beta_{fe}}) - VAR(\widehat{\beta_{re}}). \tag{18}$$

In applications where *n* is relatively large with respect to *T*, it can be used to choose between estimators. Fixed models are better under $p<0.05$ cases.

Serial correlation in the error term biases the standard errors and causes loss of efficiency. Wooldridge's test has a null hypothesis of no serial correlation in the error term of a fixed effects model, time demeaned errors of a within regression are negative serially correlated: $\rho = -1/(T-1)$. This test regresses within $\hat{v}_{it}$ estimation residuals over their lag, $\hat{v}_{i,t-l}$ using a Wald test with clustered standard errors:

$$\hat{v}_{it} = \alpha + \rho \hat{v}_{it} + \epsilon_{it} \tag{19}$$

Random effects models can be tested by Baltagi and Li's Lagrange multiplier test for first-order serially correlated errors with the joint null hypothesis of serial correlated and random individual effects. The LM test is based on the OLS residuals and it is asymptotically distributed as a X_2^2.

4. Results

Standard rule of interest rate parity was supported by the panel regression between currency logarithmic returns and 10Y premiums with a significant positive coefficient of 0.008. Fixed effects was preferred by Hausman's test, however this setup is affected by serial correlation according to the Wooldridge's test. Individual effects were significant for Norway (-0.007377) and Switzerland (0.010549). There was no serial correlation under random effects model (Baltagi and Li's test p-value = 0.1691), but 10Y premium wasn't significant under this setup.

Table 2
Panel: Fixed effects (within) (FE) model between currency differentials and interest rate premium

N = 255 n = 3 T = 85 (Balanced panel)
R-squared = 0.01244 Adj R-squared = 0.00064
Wald F(1, 251) = 3.162952 p-value = 0.0765
RSS = 0.103728 ESS = 0.002876 TSS = 0.002876

diff currency |	Coefficient	Std. Error	t-stat	p-value
10Y premium |	**0.007681**	0.004319	1.7785	0.077 *

Notes: Hausman's test of specification p-value = 0.0279, Wooldridge's test for serial correlation p-value = 0.1983

Inclusion of BSRs increased the coefficient of determination, while currency log differentials has significant relations towards corrected balance sheet expansion and security accumulation. Random effects (RE) model was selected by Hausman's test, however it has poor serial correlation. Serial correlation could be removed after the exclusion of 10Y premium, with a Baltagi and Li's p-value = 0.0659, R-squared = 0.04294 and securities as sole significant (p = 0.006) variable with a coefficient of 0.017050. Both results are suggesting a positive relationship between security accumulation and exchange rate movements.

Table 3
Panel: Random effects (RE) model between currency differentials, interest rate premium and BSRs

N = 255 n = 3 T = 85 (Balanced panel)
R-squared = 0.04998 Adj R-squared = 0.01908
Wald Chi2(8) = 12.941349 p-value = 0.1139
RSS = 0.100619 ESS = 0.005985 TSS = 0.005985

diff currency |	Coefficient	Std. Error	z-stat	p-value
10Y premium |	-0.004651	0.003446	-1.3496	0.177
leverage |	0.000878	0.001135	0.7731	0.439
transparency |	0.001910	0.012443	0.1535	0.878
lending |	0.002489	0.006169	0.4034	0.687
securities |	**0.020057**	0.006616	3.0317	0.002 ***
FX_reserves |	-0.000124	0.000121	-1.0272	0.304
BS_expansion |	**0.007092**	0.003480	2.0380	0.042 **
swap |	-0.001816	0.010877	-0.1669	0.867
CONST |	**-0.009645**	0.004977	-1.9378	0.053 *

sigma_mu = 0.000000 rho_mu = 0.000000
sigma_v = 0.020279 sigma_1 = 0.000000
theta = 0.000000

Source: own calculation, Panel Data Toolbox

Notes: Hausman's test of specification p-value = 0.9996, Baltagi and Li's test for serial correlation and random effects p-value = 0.0414

5. Conclusions and policy implications

Low growth and deflation became usual on the European continent since the Autumn of 2008. Central banks tried to manage the situation trough their key instrument at first, with a zero-lower bound as a result. After short-rate interest rates lost most of their power, monetary policy focused on longer maturities and security market operations (repos or outright) become more common. This study points on the recent changes in the well-known interest rate parity rule, with a significant connection between currency rates and accumulated securities in the central bank balance sheet (after some correction with international reserves). Safe haven currency issuers are the subject of appreciation under turbulent times. After the introduction of negative policy rates and upper exchange bands, these central banks can use the tool of open market operation as an additional tool for easing.

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