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CREDIT RISK OF FX LOANS IN POLAND. INTEREST AND FX RATE DEPENDENCE

Abstract. One of important financial stability risks in Poland is relatively high share of bank loans denominated in foreign currency extended to unhedged borrowers. Banks engaged in FX lending are exposed to indirect exchange rate risk (as a component of credit risk) through currency mismatches on their clients' balance sheets. A significant depreciation of Polish zloty would translate into an increase of value of outstanding debt (also in relation to the value of collateral) as well as in the flow of payments to service the debt. As a result, the debt-servicing capacity of unhedged domestic borrowers would deteriorate, leading to a worsening the financial condition of the private sector. The reduction of borrower's ability to service the loan and lower recovery rate affects the loan portfolio quality, increases banks' loan losses. This effect can be mitigated or intensified by foreign interest rates of extended FX loans (i.e. LIBOR). The borrower's ability to service such loan depends strongly on FX rate but also on monetary authorities from abroad. Therefore both risks are linked and should be considered together. This paper presents the statistical analysis of the dependence of foreign interest rates and FX rate of Polish zloty using measures of dependence, amongst others, copula function approach.
Keywords: financial stability, credit risk, dependence measures, copula.

1. Introduction

The presence of FX lending is significantly diversified across the European countries. Looking at the share of FX lending to the non-financial private sector it may be noted that it is relatively high in CEE countries and Austria. On the other hand, in most Western European countries, lending in foreign currencies accounts for a relatively negligible share of total loans.

The currency structure of FX lending also differs across EU countries. In the majority of countries (i.e. Bulgaria, Latvia, Lithuania, Romania) FX loans have been extended dominantly in EUR which seemed to be a natural choice given the EU membership and, in particular, regimes of exchange rates fixed to EUR.

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On the other hand, in some countries the dominant role was played by other currencies, especially Swiss franc (e.g. Austria, Hungary, Poland).

In countries with high share of FX lending, the phenomenon is often visible in both lending to households and to non-financial corporations. In contrast, countries where FX lending accounts for relatively low share of total loans, non-financial corporations tend to borrow more in foreign currencies compared with households. This seems to be an expected outcome and may be linked to the presence of export-oriented companies as well as overall degree of trade openness and country's trading partners.

Banks engaged in FX lending are exposed to indirect exchange rate risk (as a component of credit risk) through currency mismatches on their clients' balance sheets. A significant depreciation of the local currency would translate into an increase in the local-currency value of outstanding debt (also in relation to the value of collateral) as well as in the flow of payments to service the debt. As a consequence, the debt-servicing capacity of unhedged domestic borrowers would deteriorate in such a scenario, leading to a significant deterioration in the financial condition of the private sector. The reduction of borrower's ability to service the loan and lower recovery rate affects the loan portfolio quality, increases banks' loan losses and puts pressure on earnings and capital buffers.[1]

Therefore the risks to financial stability are predominantly high in countries with large stock of FX loans granted to unhedged borrowers. Particularly households and some non-financial corporations (i.e. small and medium-sized enterprises active at country's domestic market) tend to be unhedged (i.e., exposed to a currency mismatch) as their income is generally in local currency.

The share of FX lending increased since December 2004 until now across essentially all countries except for Austria. At the same time, the share of FX deposits held by the non-financial private sector in these countries increased slightly, or, in some cases, even declined (except for Latvia, where FX deposits increased notably). These asymmetric shifts in favour of FX lending could serve as a crude sign of rising currency mismatches on the non-financial private sector's balance sheets

In the referred CEE countries FX loans have been financed to a large extent by cross-border borrowing in the form of credit lines from parent institutions residing in the rest of the EU.

Loans were mostly denominated in or indexed to foreign currency and the funding was in (or was transformed into) foreign currency, but borrowers received loans in local currency. This means that institutions were selling FX funds, sourced from parent companies or wholesale markets, or received under

[1] Interesting research on influence of macroeconomic variables on banks' losses are presented e.g. in Gizycki (2001), Kearns (2004), Głogowski (2008).

swap contracts, on the spot market, exerting an upward pressure on domestic currencies.

The causes of FX lending growth where almost the same. They are as follows:[2]

- The lower stage of development of national capital markets in CEE countries – compared with the euro area countries. Specifically, the relative scarcity of longer maturity local currency debt instruments - which could serve as pricing benchmarks or be used to raise long-term funding - could have discouraged institutions from engaging in long-term local currency lending. High costs of securitisation for domestic currency instruments represented another factor, which contributed to the facts that banks obtained their funding for mortgage loans in foreign currency.
- Financing within an international financial group constituted a relatively cheaper source of funding
- Significant interest rate differentials. One of the characteristics of economies undergoing the catching-up process is a higher equilibrium interest rate due to higher potential GDP growth. Borrowers preferred FX loans because of their lower cost. Institutions could set higher profit margins and fees compared with domestic currency loans and thereby improve their financial standing.

2. Relation of interest rates and currency movements

In the countries with fixed/pegged regime, exchange risk of FX loans has not materialised during the crisis, given that local currencies did not devalue and remained pegged to the euro. As a consequence, borrowers in foreign exchange did not suffer from currency devaluation but rather benefited from EUR-interest rate cuts. In case of floating exchange rate countries, the impact of domestic currency depreciation depended heavily on the pricing regimes followed by banks extending different type of loans.

Interaction between changes of domestic exchange rate and foreign interest rates was a result of specific situation in advanced economies and on global financial markets during the recent crisis. In case of domestic currency depreciation combined with a rise in foreign interest rates, the floating exchange rate countries would have faced an increase in borrower default risk, regardless of credit pricing regime.

Observing the patterns of interest rates variability in developed countries and comparing them to developing countries' foreign exchange rates some conclusions can be drawn. Figures 1 and 2 present time series of interest rates and FX rates in the

[2] Following conclusions are made amongst others, basing on information from Financial Stability Reports (FSR) of CEECs.

same period of time. It can be noticed, that in times of economic contraction (2001 and 2002) – see Figure 1, when stock market indices were at lowered levels, currencies of developing countries depreciated (Figure 2) and then interest rates (also in developed countries) were decreasing (Figure 3). The reverse dependence was in times of prosperity (2006 and 2007).

Therefore such hypothesis is worth verification, that in times of global financial markets, when economies are dependent, global recessions increase risk aversion and emerging economies' currencies (with floating FX rates) depreciate. Recession in advanced economies results in their lower interest rates.

Therefore FX rate of emerging economies should be adversely correlated to interest rates of advanced economies which will be tested in the next paragraph.

At this point the question of interest rate parity should be raised. Does the theory of the real interest rate parity can support this reverse dependence? The parity condition indicates that real interest rates will equalise between countries and that capital mobility will result in capital flows that eliminate opportunities for arbitrage. But does it work in crisis times, when risk aversion is so high that investors do not care about profits but they search only for countries of high credibility? The experience of the last global financial crisis suggests more behavioral explanations.[3]

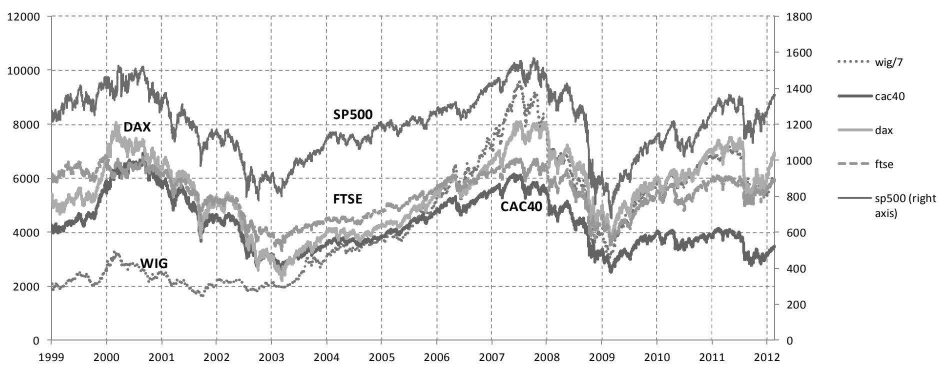


Figure 1. Stock market indices: SP500, FTSE, DAX, CAC40 and Warsaw Stock Market Index (WIG)

[3] This chapter is the first part of broader research and this part presents more statistical approach. The second step is to put the main hypothesis into economic theories' context, amongst others, into interest rate parity theories, especially behavioural exchange equilibrium rate (BEER) theory, see for example Kelm (2010).

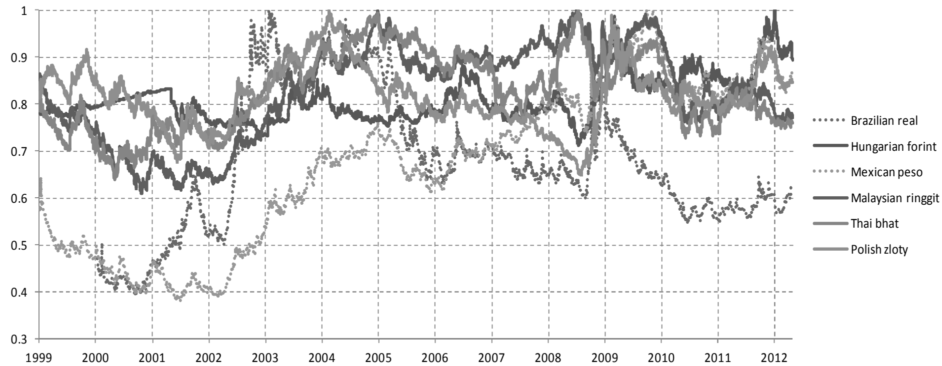


Figure 2. Developing countries' exchange rates against US dollar: Brazilian real, Hungarian forint, Mexican peso, Malaysian riggit, Thai baht and Polish zloty

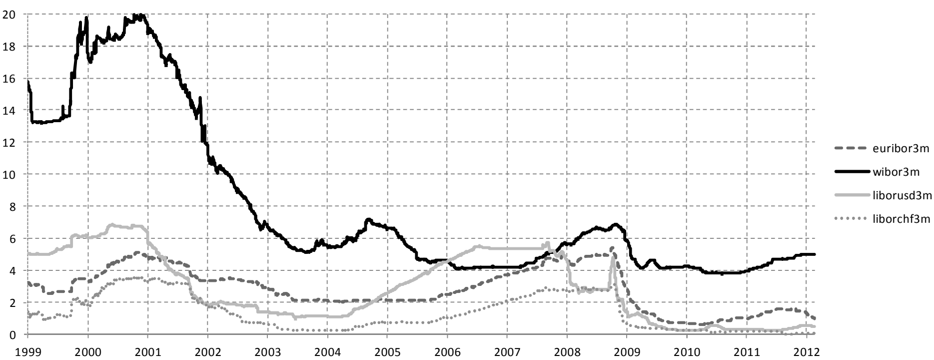


Figure 3. Interbank interest rates: LIBORUSD3m, LIBORCHF3m, EURIBOR3m and Warsaw Interbank 3-months Offered Rate (WIBOR3m).

3. Interest and FX rate dependence of foreign exchange loans in Poland

The problem of FX lending strongly affects Polish banking sector. Nearly 35% of total loans to nonfinancial sector is denominated in foreign currency. Uncovered FX risk exposure for households will last for many years because these are mainly housing loans (25% of total loans). Therefore as far as Poland has its own currency, credit risk would remain even for 20–30 years.[4]

[4] More information about situation of Polish banking system and main risk areas can be found in cyclical publication of National Bank of Poland – Financial Stability Reports (http://www.nbp.pl /homen.aspx?f=/en/systemfinansowy/stabilnosc.html)

The majority of mortgage loans were extended when Polish zloty value was at historic highs (2006–2008). New loans were then denominated mainly in Swiss francs, and to smaller extent – in euros. Their interest rate is based on LIBOR3MCHF or EURIBOR3M.

From the beginning of 2009 when Polish zloty strongly depreciated (more than 30%), the reverse dependence of FX rate and interest rate of FX loans has helped to avoid materialisation of credit risk in banking system. The question is if this reverse dependence will hold for the future? Therefore longer horizon should be tested.

The goal of the research described in this chapter is statistical assessment of some characteristics of dependence between interest rate of FX loans in Poland and FX rate of Polish zloty against Swiss franc and euro. The sample considered is the period from July 2001 to April 2012.

3.1. Simple dependence measures

It is well documented (McNeil, Frey and Embrechts 2005) that for nonelliptic distributions the linear correlation coefficient is inappropriate measure of dependence, and often can be misleading. In that case, other measures of dependence, based on the notion of concordance provide better alternatives. An example of such measures is Kendall's tau or Spearman's rho.

Spearman's rho is the measure of correlation of ranks of two random variables. Contrary to Pearson's coefficient of correlation it measures any monotonic dependence between variables, not only linear. It can be used without any assumption about the distribution of random variables. The general formula is as follows:

$$\rho_S(X,Y) = \rho(F_1(X), F_2(Y)) \tag{1}$$

where F_1 and F_2 are probability distributions of X and Y respectively.

Kendall's rank correlation measure is similar to Spearman's. Kendall's tau can be defined as the difference between probability that compared variables are in same order for two observations and the probability that compared variables are in the contrary order:

$$\rho_\tau(X,Y) = P\left[(X_1 - X_2)(Y_1 - Y_2) > 0\right] - P\left[(X_1 - X_2)(Y_1 - Y_2) < 0\right] \tag{2}$$

3.2. Copula approach

Let us assume two stochastic processes $X(t)$ and $Y(t)$ where $t = 0,1,2,\ldots,\infty$. In the simplest case $X(t) = z(t)$ and $Y(t) = v(t)$ where $z(t)$ and $v(t)$ are random variables with particular cdf (normal, t-Student, gamma, Weibull, χ^2, etc.). It means, that we assume that both processes do not have systematic components (i.e. mean, autoregression or moving average components). These two data generating processes can be described basing on the sample. Additionally we assume that both variables X(t) and Y(t) are dependent and their dependence can be described by copula function from particular parametrical family of copula functions.

In financial markets applications the regular assumption posed on characteristics of time series is the assumption on the variance of the random variable, according to which it changes and is conditional (GARCH family models).

The existence and uniqueness of copulas in case of continuous marginal distributions is assured by the Sklar's theorem (1959).

The most popular in empirical applications to financial markets are copula functions from the group of Archimedean copulas and elliptic functions.[5] An example of elliptic function are Gauss' and Student's copulas. Gauss copula can be presented by the following formula:

$$C_{\boldsymbol{\rho}}^{G}(u_1,\ldots,u_k) = H_{\boldsymbol{\rho}}(\Phi^{-1}(u_1),\ldots,\Phi^{-1}(u_k)), \tag{3}$$

Where Φ is the cdf of multivariate standard normal distribution with matrix of correlations $\boldsymbol{\rho}$. Density function of Gauss copula has the following formula:

$$c_{\boldsymbol{\rho}}^{G}(u_1,\ldots,u_k) = \frac{1}{\sqrt{|\boldsymbol{\rho}|}}\exp\left(-\frac{1}{2}\varsigma^{T}(\boldsymbol{\rho}^{-1}-\mathbf{I})\varsigma\right), \tag{4}$$

where

$$\varsigma = (\Phi^{-1}(u_1),\ldots,\Phi^{-1}(u_k))^{T},$$

and Φ is cdf of standard normal distribution.

[5] The broad review of copula models can be found e.g. in Patton (2012).

Student's t copula:

$$C^{S}_{\rho,\nu}(u_1,...,u_n) = T_{\rho,\nu}(T^{-1}_{\nu}(u_1),...,T^{-1}_{\nu}(u_n)) \tag{5}$$

Where $T_{\rho,\nu}$ is cdf of standard Student's distribution with ν degrees of freedom and correlation matrix ρ. T_{ν} is cumulative distribution of univariate Student t distribution with ν degrees of freedom. Density of the distribution has the formula as follows:

$$c^{S}_{\rho,\nu}(u_1,...,u_n) = |\rho|^{-\frac{1}{2}} \frac{\Gamma\left(\frac{\nu+n}{2}\right)\left(\Gamma\left(\frac{\nu}{2}\right)\right)^{n}\left(1+\frac{1}{\nu}\varsigma^{T}\rho^{-1}\varsigma\right)^{-\frac{\nu+n}{2}}}{\left(\Gamma\left(\frac{\nu+1}{2}\right)\right)^{n}\Gamma\left(\frac{\nu}{2}\right)\prod_{i=1}^{n}\left(1+\frac{\varsigma_i^2}{\nu}\right)^{-\frac{\nu+1}{2}}} \tag{6}$$

where $\varsigma = (\varsigma_1,...,\varsigma_n) = (T^{-1}_{\nu}(u_1),...,T^{-1}_{\nu}(u_n))$.

The other important classes of copulas are Archimedean copulas. Function C is an Archimedean copula if it can be presented by the following general formula:

$$C(u_1,...,u_k) = \phi^{-1}(\phi(u_1)+...+\phi(u_k)) \tag{7}$$

where $0 \le u_i \le 1$, $i=1,...,k$.

$\phi:[0,1] \to [0,\infty)$ is so called generator, which is continuous, strictly decreasing and convex function ($\phi(1)=0, \phi(0)=\infty$).

Among the most popular applications in the financial markets are in this class Clayton, Gumbel and Frank copula functions with generators respectively:

$$\varphi^{Cla}_{\theta}(t) = \frac{1}{\theta}(t^{-\theta}-1), \qquad \theta \in [-1,\infty) \tag{8}$$

$$\varphi^{Gum}_{\theta}(t) = (-\ln t)^{\theta}, \quad \theta \in [1,\infty) \tag{9}$$

$$\varphi^{Fra}_{\theta}(t) = -\ln\frac{e^{-\theta t}-1}{e^{-\theta}-1}, \ \theta \in \Re. \tag{10}$$

Having known the copula which joins distributions is not sufficient to calculate the Pearson correlation coefficient. To calculate this coefficient using copula approach needs additional information about the marginal distributions.

However, in the case of Kendall's and Spearman's coefficient (also the Gini coefficient and Blomqvist) derivation of the value using only copula function (without a marginal distribution) is possible (See more in Wanat 2011).

3.3. Tail dependence

The most interesting from a practical point of view is the relationship between random variables in the tails of distributions. Using the methodology of copula functions one can calculate tail dependence coefficients (TDC). They measure the conditional likelihood of extreme values of one variable on condition of extreme values of the other variable.

Depending on whether the study of interest is the left or right side of the distribution, there are two types of TDC: the lower and upper coefficient (λ_L and λ_U):

$$\lambda_L = \lim_{u \to 0} P(X_1 \le F_1^{-1}(u) | X_2 \le F_2^{-1}(u))$$

$$\lambda_U = \lim_{u \to 0} P(X_1 > F_1^{-1}(u) | X_2 > F_2^{-1}(u))$$

For the presented above copulas following tail dependence coefficients can be calculated:

– Gauss copula: $\lambda_L = 0$, $\lambda_U = 0$ for $\rho < 1$

– Student t copula: $\lambda_L = \lambda_U = 2(1 - t_{\nu+1})(\sqrt{\nu+1}\frac{1-\rho}{1+\rho})$

– Clayton copula: $\lambda_L = 2^{-\frac{1}{\theta}}$, $\lambda_U = 0$

– Gumbel copula: $\lambda_L = 0$, $\lambda_U = 2 - 2^{\frac{1}{\theta}}$

– Frank copula: $\lambda_L = 0$, $\lambda_U = 0$.

It should be noted that the Gaussian and Frank copulas have properties depending on the tail of the distribution (asymptotic independence at extreme values), while in the case of t-copula the relationship is reciprocal.

Copulas were estimated using two-step maximum likelihood method. In this method the marginals are estimated in the first step (nonparametrically) and empirical observations are transformed into a vector of pseudoobservations. In the second step dependence parameter is estimated using the copula via maximization of pseudo log-likelihood.

Number of observations used for the estimation was 3286 (daily frequency).

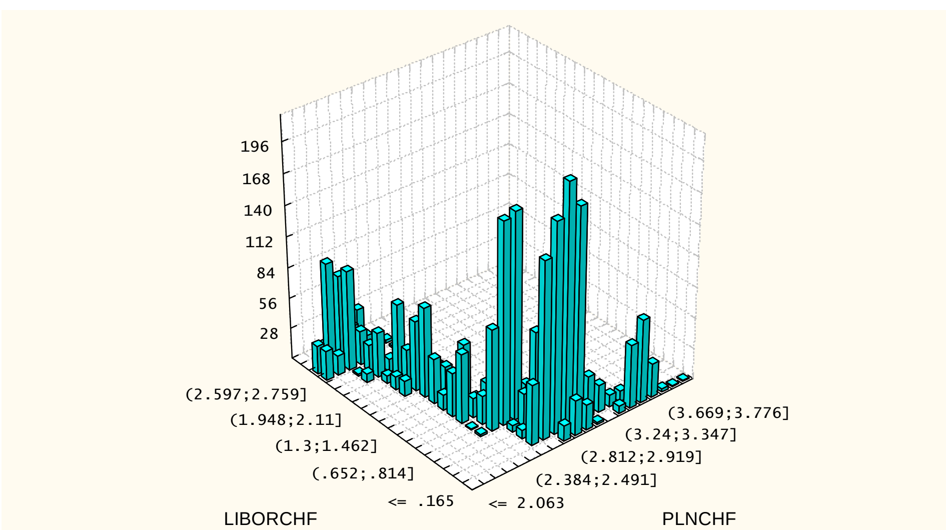
3.4. Results

Distributions of selected variables are not normal. Therefore other measures than Pearson coefficient should be taken into consideration. In the first step computed values of Spearman's and Kendall's coefficients confirm the hypothesis. The reverse dependence is relatively strong in case of relation between value of Polish zloty against Swiss currency and LIBOR3MCHF. Spearman's rho is around –0.9 (See Table 1). PLN/EUR and EURIBOR3M dependence is relatively weaker, but reverse, as supposed.

Table 1. Simple measures of dependence between empirical distributions of FX rate of Polish zloty and interest rates

	Pearson	Spearman	Kendall
PLN/CHF – LIBOR3MCHF	–0.8291	–0.9172	–0.7524
PLN/EUR – EURIBOR3M	–0.6232	–0.6573	–0.4625

Source: own computations.



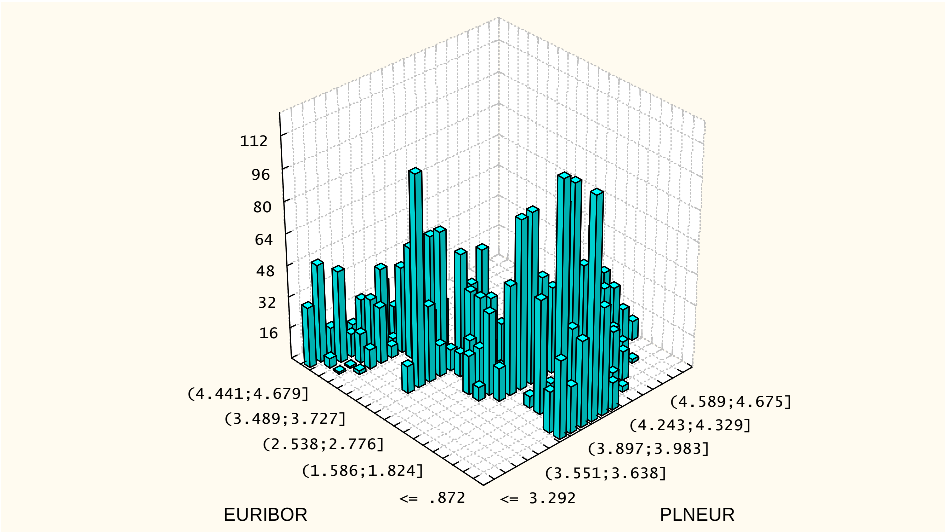


Figure 4**.** Empirical multivariate distributions of FX rate of Polish zloty and interest rates
Source: own computations.

According to Akaike and Bayesian information criterion (computed using log-likelihood function values) in case of LIBORCHF-CHFPLN dependence, the best fitted copula from considered group was Plackett's (See Table 2). This fact can suggest, that for this pair, the tail dependence is rather weak. The high ranks for copulas with symmetric tail dependence prove that dependence in extreme values, no matter if the currency is very strong or very weak, was the same.

Table 2. Results of copula estimations. Best fitted copulas (first row includes the best one). Relation LIBORCHF – CHFPLN

liborchf-chfpln

Copula name	Log-likelihood	AIC	BIC	Lower tail dependence	Upper tail dependence
Plackett	–2790	–5580	–5580	0	0
Student's t	–2540	–5088	–5088	0.6	0.6
Normal	–2420	–4840	–4840	0	0
SJC	–2120	–4256	–4256	0.6	0.6
Clayton	–2010	–4021	–4021	0.8	0

Source: own computations.

Table 3. Results of copula estimations. Best fitted copulas (first row includes the best one). Relation EURIBOR – EURPLN

euribor–eurpln

Copula name	Log–likelihood	AIC	BIC	Lower tail dependence	Upper tail dependence
Rotated Clayton	–1339	–2678	–2678	0	0.7
SJC	–1335	–2671	–2671	0	0.7
Gumbel	–1093	–2186	–2186	0	0.6
Plackett	–777	–1553	–1553	0	0
Student's t	–772	–1544	–1544	0.1	0.1

Source: own computations.

Although the Spearman's and Kendall's relation measures indicate weaker dependence of the pair EURIBOR and EUR/PLN, copulas which were the most suitable in that case reflect quite strong upper tail dependence (See Table 3). This means, that in times of high interest rates and relatively strong Polish currency, the variability of both series had similar patterns.

The results are ambiguous to confirm the hypothesis presented in section 2. From the one hand, symmetry of tail dependence in case of estimated copulas for liborchf-chfpln supports the idea, but zero value of tail dependence measure for best fitted copula indicates the higher possible losses in case of chf loans (no adverse effect of FX and interest rate). More optimistic view from credit risk perspective presents relation between euribor and eurpln rate. Relatively strong adverse effect between FX and interest rate in times of weak Polish zloty would reduce the credit risk.

4. Conclusions

Statistical inspection of basic properties of relations between interest rates and FX rates in case of FX loans in Poland proved the existence of the reverse relation in the sample period. This reverse dependence of FX rate and interest rate of FX loans has already helped to avoid materialisation of credit risk in the banking system. Therefore global fluctuations of economy are possibly not a danger for Polish borrowers provided that Swiss and Euro Area remain stable economies. Credit risk for the banking system would increase in periods of recovery and economic boom (when interest rates of developed countries are relatively high) and increasing Poland's specific risk (i.e. debt crisis, banking system default etc.).

The risk might materialise e.g. in the case of a sudden stop scenario, which would involve capital outflows and depreciation of currencies of emerging markets, as well as of some EU Member States where FX lending plays an important role.

Further research should include broader analysis of dependence between other emerging markets' exchange rates and interest rates of developed countries, applying the methodology of time-varying dependence using conditional copulas, simulations of different scenarios from borrowers perspective (including income buffers) using extreme values from bivariate distribution and inter alia, simulations for particular banks in the system and aggregate effect.

References

Alexander C. (2010), Market Risk Analysis: Practical Financial Econometrics, Wiley.

Doman M., Doman R. (2010), Copula Based Impulse Response Analysis of Linkages Between Stock Markets, SSRN Working Paper Series, No. 1615108.

Financial Stability Report (2012), National Bank of Poland, http://www.nbp.pl/ homen.aspx?f=/en/systemfinansowy/stabilnosc.html.

Financial Stability Report (2013), National Bank of Poland, http://www.nbp.pl/ homen.aspx?f =/ en/systemfinansowy/stabilnosc.html.

Gizycki M. (2001), The effect of macroeconomic conditions on banks' risk and profitability, Reserve Bank of Australia Research Discussion Paper, 6.

Głogowski A. (2008), Macroeconomic determinants of Polish banks' loan losses – results of a panel data study, National Bank of Poland Working Paper, 53.

Kearns A. (2004), Loan losses and the macroeconomy: A framework for stress testing credit institutions' financial well-being, Financial Stability Report, Central Bank and Financial Services Authority of Ireland.

Kelm R. (2010), Model behawioralnego kursu równowagi złotego do euro w okresie styczeń 1996 – czerwiec 2009 r., Bank i Kredyt, 41 (2), 2010, 21–42.

McNeil A.J., Frey R., Embrechts P. (2005), Quantitative Risk Management: Concepts, Techniques, and Tools, Princeton Series in Finance.

Patton A.J. (2006), Modelling Asymmetric Exchange Rate Dependence, International Economic Review, Vol. 47, No. 2, pp. 527–556.

Patton A.J. (2012), A review of copula models for economic time series, Journal of Multivariate Analysis, 110, pp. 4–18.

Sklar A. (1959), Fonctions de répartitions á n dimensions et leur marges., Publications de l'Institut de Statistique de l'Université de Paris, vol. 8, pp. 229–231.

Trivedi P.K., Zimmer M. (2005), Copula Modelling: An Introduction for Practitioners, now Publishers Inc.

Wanat S. (2011), Modelowanie struktur zależności za pomocą funkcji połączeń w analizie ryzyka ubezpieczyciela, Acta Universitatis Lodziensis, Folia Oeconomica, 254, 89–107.

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RYZYKO KREDYTOWE POŻYCZEK WALUTOWYCH W POLSCE. ZALEŻNOŚĆ STOPY PROCENTOWEJ I KURSU WALUTOWEGO

Streszczenie

Jednym z najważniejszych zagrożeń stabilności finansowej w Polsce jest stosunkowo wysoki udział kredytów bankowych w walutach obcych udzielonych niezabezpieczonym kredytobiorcom. Banki które udzielały kredytów walutowych są narażone pośrednio na ryzyko kursowe (jako element ryzyka kredytowego) za sprawą niedopasowania walutowego w bilansach swoich klientów. Znacząca deprecjacja złotego przekłada się na wzrost wartości zadłużenia (również w stosunku do wartości zabezpieczenia), jak również na bieżące płatności kredytobiorcy. W rezultacie, zdolność obsługi zadłużenia przez niezabezpieczonych kredytobiorców krajowych ulegałaby pogorszeniu, co prowadzi do pogorszenia się kondycji finansowej sektora prywatnego. Zmniejszenie zdolności kredytobiorcy do obsługi kredytu i niższy poziom odzysku mają wpływ na jakość portfela kredytowego i zwiększają straty kredytowe banków. Efekt ten może być zmniejszony lub zwiększony przez zagraniczne stopy procentowe obowiązujące dla udzielanych kredytów walutowych (np. LIBOR). Zdolność kredytobiorcy do obsługi takiego kredytu zależy nie tylko od kursu walutowego, ale również od władz monetarnych z zagranicy. Dlatego oba ryzyka są ze sobą powiązane i powinny być rozpatrywane łącznie. W artykule przedstawiono analizę statystyczną zależność zagranicznych stóp procentowych i kursu złotego przy użyciu miar zależności, między innymi, podejście za pomocą funkcji copula.