Changing patterns in the dependence of long-term rates between Poland and major financial centres

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Abstract

The accommodative monetary policy of major central banks has resulted in strong capital inflows into emerging economies. We investigate the extreme dependence – effectively, contagion – between long-term interest rates in core markets and those of Poland in recent years. The issue is particularly important from a financial stability standpoint. Using a copula framework, we demonstrate that the dependence of extreme events has actually eased in recent years as the structure of foreign investment holdings in Poland has become more stable. Given the elevated risk of contagion, however, these developments should not lull one into a false sense of security. The propensity of bond yields to crash in synchrony should be closely monitored, especially in turbulent periods.

Keywords: Copulas, dependence, contagion, long-term interest rates, Poland

JEL classification: C58, G15

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The authors would like to acknowledge Janusz Zieliński for his comments on market developments in Poland and emerging market economies as well as on international capital flows.

1. Introduction

The recent financial and economic crisis was followed by an unprecedented monetary policy response. The major central banks adopted a highly accommodative monetary policy stance, cutting their policy interest rates to near zero. Then, as the zero bound on nominal interest rates is a significant constraint on central bank action, further stimulus was provided by large-scale bond purchases or other unorthodox tools. Although the four major central banks adopted different forms of quantitative easing, all these programmes led to a massive expansion of their balance sheets and hence the monetary base.

Many indicators for global liquidity conditions can be devised (Eickmeier, Gambacorta and Hofmann (2013)), but a rise in the monetary base in the major developed countries serves as a good proxy. Based on this indicator, it needs to be stressed that major central bank policies, both standard and unconventional, have had a huge impact on global liquidity expansion, as it was termed by the IMF (2010). It became increasingly easy for investors to access funding at historically low costs during 2009–13. The environment of low funding costs and ample global liquidity was identified by many authors as the basic channel by which accommodative monetary conditions were transmitted from the industrialised countries to emerging market economies (EMEs). The large spillover effects experienced by EMEs resulted from sizeable portfolio capital flows to local equity and debt markets, which put exchange rates under significant appreciation pressure in some countries. Thus, even if the major central bank actions did not initially result in a much-feared inflation, they may have contributed to the potential build-up of imbalances that pose a threat to a wider economic stability.

In this paper we deal with the relationship between long-term rates in major financial centres and Poland in recent years. This is an important issue for central banks. Decisions by foreign central banks may interfere with the local monetary policy by putting pressure on the spreads between the two markets. This can in turn affect the spending decisions of local consumers and enterprises. While the overall dependence of Polish long-term rates may have increased in recent years, ordered flows to and from Poland do not pose a problem. In the context of excessive global liquidity expansion, however, it is worth noting that there is some evidence in the literature that a large proportion of activity by non-residents in government bond markets can induce higher volatility in local bond prices. Large changes in rates abroad, if transmitted to local markets, may be hazardous to the country's financial stability. Thus, the question of how far domestic long-term rates are dependent on large movements in foreign long-term rates is a central concern for any central bank. The contribution of the present study is the evidence that in Poland this sensitivity to extreme events has actually eased over the period of rapid capital inflows, possibly due to an improvement in the structure of foreign holdings. Nevertheless, further results suggest that, even if contagion has generally diminished in recent years, in some periods it returns with a force that needs to be treated as a warning signal.

The structure of the paper is as follows. In the next section, we present some stylised facts on portfolio inflows during the recent financial crisis. In the third section, we introduce the main tool used to investigate the propensity of markets to boom or crash together, the so-called copula function. Copulas were used in an earlier study executed at the National Bank of Poland (Adam, Bańbuła and Markun

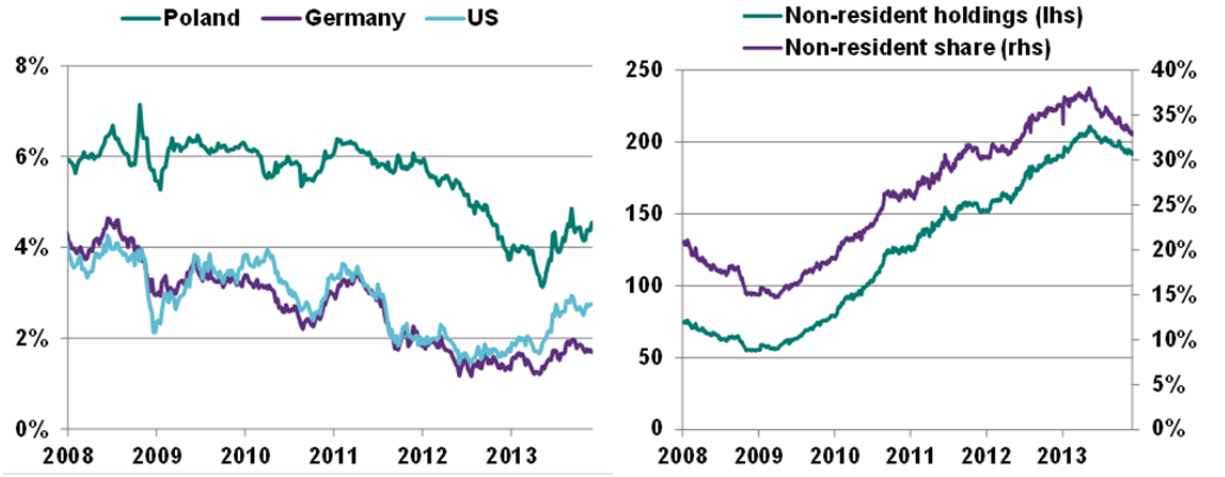
(2013), henceforth ABM). We present their main findings and explain how the methodology can be adapted to answer the current question. Finally, in the fourth section we conclude.

2. Foreign portfolio investment in Polish government debt in 2009–13

During 2009–12, several EMEs saw average net foreign portfolio inflows into debt instruments of more than 3% per year. As Polish government debt market was a favourite destination for this type of foreign portfolio investment, non-residents' holdings of the country's domestic sovereign debt surged to 38% before the May–June 2013 turmoil in EME financial markets. In principle, a country receiving large inflows benefits from a strong compression of yields and/or a reduction in CDS premia. And large capital inflows, together with short term interest rates that were falling towards historical lows, did indeed lead to a significant compression of yields on Polish long-term government bonds (Figure 1). But capital flows started to reverse to some extent on the Fed's announcement of a possible "tapering" in its quantitative easing.

Yields on Polish and core market sovereign bonds and non-resident holdings of Polish government debt

Figure 1



Notes: Left-hand panel plots the yields on Polish, German and US government 10-year debt. Right-hand panel plots non-resident holdings both in absolute terms (PLN bn), as well as relative to the whole stock of Polish government debt (%).

Sources: Bloomberg, Central Securities Depository of Poland.

Andritzky (2012) argues that, in general, a heavy presence of non-residents in government bond markets leads to lower yields on domestic debt, but at the same time it may induce higher volatility in local bond prices. This is due to the tendency of non-residents to respond to greater range of variables than domestic investors. Such variables may include, for example, exchange rates, global market sentiment or a change in funding costs in developed markets. That said, the Polish case shows that additional factors may come into play that counteract these effects. We argue that the stability of the investment holding structure also matters because it can mitigate the negative externalities arising from the increased presence of

non-residents in government bond markets. The Polish experience shows that, if long-term investors predominate, then a stable base of investors can act as an important buffer against global headwinds, serving to mitigate the transmission of global volatility into domestic financial assets.

Between the fourth quarter of 2008 and the EM turmoil, non-residents' holdings of Polish government bonds increased by about PLN 150 billion. This translated into large gains in the market share of non-residents, which has risen by about 23 percentage points over the last five years. At the same time, the structure of foreign investors' holdings changed significantly. The holdings of foreign banks fell by about 10 percentage points to 15%, and were replaced by portfolio investments made by non-banking financial institutions, whose market share now amounts to about 80%. From the financial stability standpoint, the most important question concerns the characteristics of this group. The category is far from homogenous as it includes long-term investors, often called real money accounts, as well as hedge funds and the rest of the "leverage community". The former group seems to be welcomed by local authorities as the most stable type of investor, while the latter group poses the biggest potential risk to financial system stability. Based on historical precedents such as the large portfolio outflows from the Polish debt market in 2008, we estimate the share of leveraged funds at 6% of outstanding foreign investment in Polish government debt. This is clearly hot money, which is liable to overreact to changes in global investment sentiment. However, it should be stressed that foreign banks may also induce volatility on the debt market as their investments are often motivated by the expectation of capital gains. Foreign banks have been especially active during the monetary policy easing cycle. However, this category of investors, as already highlighted, appears to have lost some of its importance, with its share of total marketable fixed rate government debt now falling below 5%.

In 2013, Poland and other EMEs experienced capital outflows from their debt markets (Figure 1) following the Fed's announcement of possible tapering. The increase in global risk aversion led to the reversal of portfolio flows driven by the search for yield. Between May and June, yields on Polish longer-term government bonds rose by about 110 bps as foreign investors sold off government bonds worth about PLN 5.3 billion.[4] In the aftermath of the May–June turmoil, capital outflows tended to persist, although on a much smaller scale. Compared to the end of April 2013, non-residents reduced their long positions in the government bond market by PLN 13.9 billion, reversing almost all the inflows recorded in the first four months of 2013. As a result their share in total marketable government debt fell by 3.7 percentage points between May and December, easing to 33.6% at the 2013 year-end. Despite continuing capital outflows after the May–June turmoil, the yields on long-term government bonds behaved in a more stable way, moving in a wide range of 4.1–4.5%. This suggests that, while ordered capital outflows need pose no threat to the stability of government bond market, rapid and massive outflows can lead to the violent adjustment of local interest rates, with possibly damaging implications for the real economy.

[4] However, portfolio flows suggest that foreign capital may not have left the country in its entirety, a conclusion that is further reinforced by the broadly stable exchange rate.

3. Copulas and tail dependence to assess extreme events

We next investigate more formally and from a financial stability standpoint the recent changes in the way that developments in global markets are transmitted to the situation in Poland. We ask ourselves how likely it is that large changes in a given foreign market translate to a large change in the respective market in Poland. We employ and extend the ABM methodology based on the *copula* functions.

It is now well known that the simple measure of Pearson correlation is inadequate description of the dependence between financial assets. On the other hand, Sklar's theorem says that any multivariate distribution can be decomposed into marginal distributions of the variables among which the dependence is being investigated and a dependence itself, captured fully by a function called a copula. This is succinctly summarised by the following equation:

$$H(x_1, \dots, x_n) = C\big(F_1(x_1), \dots, F_n(x_n)\big), \qquad (1)$$

where H is an n-dimensional distribution function with marginal distributions F_1,...,F_n, and C is a copula function. To analyse dependence between Polish and foreign financial assets, ABM implement a thorough specification search of both marginal (conditional heteroscedasticity models) and copula distribution functions (nine parametric families), based on information criteria as well as state-of-the-art bootstrap goodness-of-fit tests for copulas, to choose the best among the wide range of parametric models for further inference. It turns out that a useful measure can be derived from a copula, the so-called (lower or upper) *tail dependence coefficient* (hereinafter TDC). The coefficients[5] describe the propensity of markets to crash or boom together, ie they measure the dependence between extreme outcomes of the analysed variables, a phenomenon which is often dubbed a *contagion*. For comparison, if correlation is a measure of total dependence between two variables, TDCs describe dependence during stress periods only. Importantly, for the copulas considered in this paper the TDCs are simple functions of copula parameters.[6]

ABM analyse daily data from 1 March 2000 to 30 June 2012 on roughly the same data as we do in the present study to identify the sectors of the Polish financial market that are particularly vulnerable to contagion. Two conclusions are especially relevant. First, for the pairs of variables among which dependence is measured in the present work, the symmetrised Joe-Clayton (SJC) copula is admissible and often the optimal. The SJC copula is very attractive as it allows us to model the dependence in the times of booms and crashes independently. Second, asset classes differ greatly in their susceptibility to contagion, and the responses to upturns and downturns in global markets are often asymmetric: equities and the currency appear prone to contagion from all international markets under

[5] Formally, the upper (lower) TDC is a limiting probability of one variable exceeding (falling behind) a high-order (low-order) quantile, given that the other variable exceeds (falls behind) the same quantile.

[6] It is important to remember that the choice of a particular copula may in some cases restrict admissible asymptotic dependence, eg Gaussian copula implies asymptotic independence, t-Student's copula implies that upper and lower asymptotic dependence have the same strength.

consideration, while Polish bonds exhibit rather limited contagion from foreign markets (two-year bonds do not seem to be affected by any of the external factors considered; for 10-year bonds, the contagion is visible, though relatively weak compared with other asset classes).

It has to be acknowledged that the cited analysis, although based on a very sound methodology, is limited in at least one important respect. As it is static, it does not allow us to analyse the dynamics of the dependence, and thus, to assess if the influence of long-term rates in major financial centres has changed in recent years. A straightforward solution implemented here, broadly preserving the methodological rigour, is to split the sample into two subperiods – pre-crisis and crisis. We divide the data on 15 September 2008 (Lehman Brothers bankruptcy), then fit the marginal models as well as the SJC copulas into subsamples. Finally we compute TDCs.

Since time variation in the conditional first and second moments of economic time series has been widely reported, it seems natural to assess if there exists time variation in the tail dependence between Polish and foreign economic variables as well. To this end, we consider the conditional copula in a version first presented by Patton (2006), the time-varying SJC copula[7]. We assume that the functional form of the copula remains fixed over the sample whereas the parameters vary according to the following evolution equation for the conditional upper and lower TDCs:

$$\tau_t^U = \Lambda\left(\omega_U + \beta_U \tau_{t-1}^U + \alpha_U \frac{1}{10}\sum_{j=1}^{10}\left|u_{t-j} - v_{t-j}\right|\right) \qquad (2)$$

where U stands for upper TDC, $\Lambda(x) \equiv (1+e^{-x})^{-1}$ is the logistic transformation, used to keep τ^U and τ^L in (0,1) at all times (for the equation for lower TDC substitute U with L). The right-hand side of the model for the tail dependence evolution equation contains an autoregressive term, $\beta_U \tau_{t-1}^U$, and a forcing variable (mean absolute difference between u_t and v_t over the previous 10 observations). Since there are separate equations for τ^U and τ^L, the SJC copula allows for asymmetric dependence and includes symmetric dependence as a special case. In contrast to the static copula, here we do not use goodness-of-fit tests of the copula function and there are two reasons for this. First, the other time-varying copula introduced by Patton (2006) does not allow for asymmetric tail dependence behaviour. Second, a consensus does not seem to exist in the literature as to which goodness-of-fit test should be used in case of dynamic copulas; the tests that are used appear underdeveloped and to have low power. For this reason we believe that the static copula results should be treated as more robust, while the dynamic copula results can contribute useful supplementary information.

[7] There are other methods of introducing dynamics into the specification of the copula, see eg Rodriguez (2003).

4. Changing pattern of extreme dependence between Polish and core markets

The data set at our disposal comprises foreign and Polish variables. The foreign variables include stock index and sovereign bond yields in the United States (S&P 500, US2Y, US10Y), Germany (DAX, DE2Y, DE10Y) and the CBOE Market Volatility Index (VIX), which measures the implied volatility of the S&P 500 index options and is commonly used as a market-based risk-aversion and uncertainty indicator. The Polish variables include the main stock market index (WIG), short- and long-term sovereign bond yields (PL2Y, PL10Y) and the main foreign exchange rate, quoted as the Polish zloty price of the euro (EUR/PLN). We use daily data from 1 March 2000 to 29 November 2013 obtained from Reuters (PL10Y) and Bloomberg (other variables). We transform the original data in levels into changes in yields (all sovereign bonds, percentage points) or into rates of return between two consecutive trading days as appropriate, obtaining 3,245 observations. We also use weekly data in the dynamic part of the study. Here the changes (or rates of return) are defined between Friday and the previous week's Friday, which accounts for 714 observations in total. To characterise our data set, we present descriptive statistics in Table 1. All variables exhibit high kurtosis accompanied by often high absolute skewness, which leads to strong rejections of normality of the univariate distributions (Jarque-Bera tests). ARCH effects are present in all of the variables and all but one exhibit strong autocorrelation. These characteristics motivate the use of ARMA-GARCH models for marginal distributions.

Descriptive statistics — Table 1

	Mean	Min	Max	Std. dev.	Skewness	Kurtosis	ARCH(10)	Q(20)	J-B
EURPLN	1,40E-05	–0,038	0,054	0,007	0,47	8,31	441*	54*	3935*
PL2Y	–0,0043	–1,420	0,987	0,101	–0,68	31,19	352*	112*	107670*
PL10Y	–0,002	–0,844	0,865	0,085	–0,01	22,37	417*	111*	50709*
WIG	0,0003	–0,102	0,061	0,014	–0,41	6,59	261*	37*	1834*
VIX	–0,0002	–0,437	0,496	0,065	0,60	7,41	194*	94*	2820*
DE2Y	–0,0013	–0,390	0,331	0,049	0,07	8,71	165*	49*	4411*
US2Y	–0,0019	–0,565	0,473	0,062	–0,25	10,87	327*	68*	8411*
DE10Y	–0,0012	–0,226	0,228	0,047	0,14	4,56	199*	22	341*
US10Y	–0,0011	–0,473	0,428	0,067	0,18	5,55	156*	53*	893*
DAX	5,88E-05	–0,098	0,135	0,016	0,07	8,60	538*	59*	4244*
SP500	8,33E-05	–0,095	0,104	0,014	–0,13	10,58	894*	104*	7770*

Notes: The table displays sample statistics for daily returns or changes in yields (bonds) between 1 March 2000 and 29 November 2013, spanning 3,244 observations for each series. ARCH(10), Q(20) and J-B are the Lagrange multiplier tests of no ARCH effects up to 10 lags, the Ljung-Box statistics of no serial correlation up to 20 lags and the Jarque-Bera test for normality of distribution. *, ** and *** denote statistical significance at 1%, 5% and 10% level, respectively.

Table 2 below shows the results of the estimation of TDCs in subsamples, thus reporting our assessment of the likelihood that extreme changes in asset prices have coincided in Poland and abroad. Meanwhile, Figure 2 depicts how this

assessment changes as we move from the pre-crisis to the crisis period.[8] What becomes evident is that for variables other than bond yields the tail dependence, both lower and upper, increases, sometimes significantly so. The upper tail dependence between Polish and German or US bond yields, most interestingly from the viewpoint of the central bank, is generally low. The susceptibility of Polish long rates to large moves in foreign bond yields decreases in the second subsample. This is somehow contrary to the results reported by Miyajima, Mohanty and Chan (2012) of a high degree of co-movement between the yields since 2008. Note however, that what tail dependence measures is the dependence between large changes, and the reported inflow of real-money investors in the crisis period into the sovereign bonds market in Poland, believed by the investors to have strong fundamentals, may in fact have dampened the tail dependence and brought more stabilisation to the market instead. Our finding does not therefore deny that the overall dependence may have increased as a result of a stronger integration of the Polish bonds with core markets, or following the recent change in the status of Polish debt (now described as a regional safe haven). It refers to the probability of contagion only, and it shows that this probability has eased on average since September 2008, as compared to the period March 2000–July 2008.

Estimates of extreme dependence in subsamples

Table 2

		1 March 2000–12 September 2008				15 September 2008–29 November 2013			
Poland	Foreign	τ^L	s.e.	τ^U	s.e.	τ^L	s.e.	τ^U	s.e.
EURPLN	VIX	1,4%	2,17E-02	3,0%	1,65E-02	15,0%	4,83E-02	22,0%	3,20E-02
PL2Y	VIX	0,0%	9,85E-05	0,0%	1,57E-06	0,1%	8,08E-03	0,3%	7,71E-03
PL2Y	DE2Y	1,0%	1,47E-02	2,1%	1,78E-02	0,0%	4,87E-06	0,0%	2,35E-06
PL2Y	US2Y	0,2%	4,82E-03	0,0%	3,84E-04	0,0%	9,71E-06	0,0%	1,97E-06
PL10Y	VIX	0,0%	5,95E-06	0,0%	1,49E-05	0,0%	1,99E-03	4,4%	2,64E-02
PL10Y	DE10Y	3,3%	2,31E-02	8,7%	2,71E-02	0,0%	3,89E-08	3,0%	2,25E-02
PL10Y	US10Y	2,4%	2,07E-02	1,2%	1,40E-02	0,0%	9,60E-07	0,0%	2,68E-05
WIG	VIX(-1)	8,7%	2,47E-02	1,7%	2,14E-02	21,3%	3,04E-02	12,0%	4,89E-02
WIG	SP500	11,5%	2,73E-02	7,3%	2,84E-02	18,8%	3,63E-02	37,8%	3,01E-02

Notes: The table displays the static upper and lower tail dependence coefficients and their standard errors, estimated over the two subperiods for the respective Polish-foreign pairs of assets. Nine pairs of the most representative financial instruments were chosen.

The method based on splitting the sample into pre-crisis and crisis periods maintains some of the methodological rigour of ABM, but it cannot be applied to the recent period, marked by a rise of long-term rates caused by expectations for QE tapering. The reason is that the relevant period, from May 2013 until the present, would be too short to reliably fit the static models and make inferences. Here the time-varying copulas come to the rescue by providing the contagion estimates at every period in our sample ending in November 2013. We decided to focus on the upper tail dependence between Polish and core market (US and German) long-term yields because large yield surges, which do not originate in a change in a country's

[8] The results of the marginal distributions modelling as well as other non-reported results in this study are available upon request.

fundamentals, pose a bigger threat to the stability of local debt than large yield decreases. If sizeable increases in yields are not reversed, they may prompt overreactions among foreign investors. Bearing in mind that self-fulfilling expectations may arise in financial markets, this may increase borrowing costs for the government, as well as lead to problems with debt financing and even to default.

Estimates of extreme dependence in subsamples Figure 2

Notes: The figure plots the changes of static ("average") tail dependence coefficients over two subperiods for the respective Polish-foreign pairs of assets. The left-hand panel presents lower TDCs (propensity of two markets to boom together), while right-hand panel presents upper TDCs (propensity to crash together). See Table 1 for numerical values and standard errors.

Figure 3 presents the propensity to crash from the estimation of conditional copulas. Several striking observations can be made when analysing the results. To start with, the importance of using methods which allow the tail dependence to vary over time is clearly demonstrated. TDCs fluctuate between virtually zero to as much as 44% in some periods. Our conditional copula results also cast light on the puzzle of decreased estimates between subsamples. The average dynamic estimate in the periods corresponding to subsamples from the unconditional part of the study also shows a visible decrease in the second period. In particular the average dynamic estimate decreases from 9.4% to 5.9% in the Polish-German copula, and from 6.3% to 5.9% in the Polish-US copula[9].

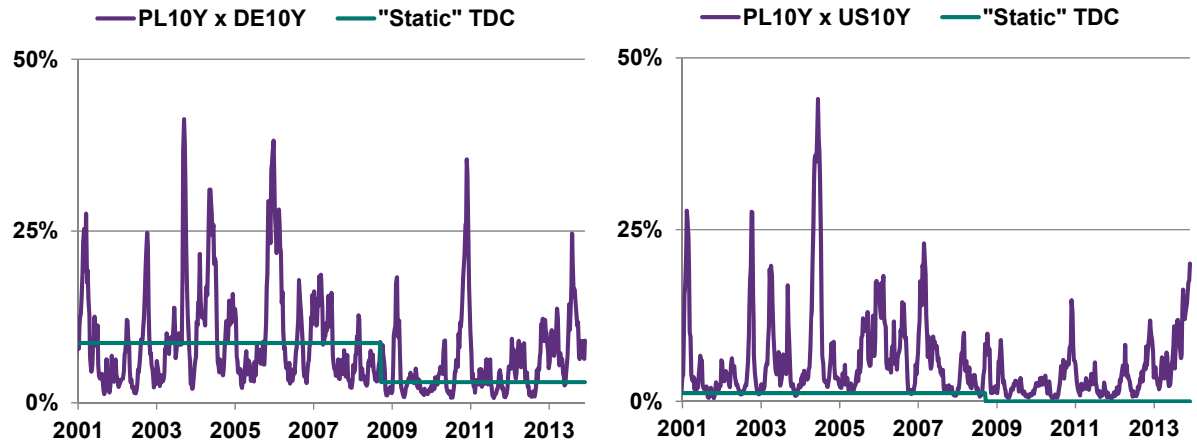
More importantly, however, if dynamic copulas were not applied, no strong contagion at several points in time would be detected. If limited to the latest financial crisis period only (starting from 2008), it appears that the most visible spikes in the extreme dependence between Polish and German yields coincide with the culmination of the sovereign debt crisis in the euro zone in November 2010 (Ireland became the second country to be bailed out), and during mid-2013, when speculation about the Fed's QE tapering mounted. The last period is even more pronounced when extreme dependence between Polish and US yields is taken into

[9] It should be pointed out, though, that SJC copula is not closed under temporal aggregation, so if the conditional copula is SJC, the unconditional copula does not need to be SJC in general. Moreover, the use of different frequencies also explains part of this problem.

account. As a matter of fact, it surges to the highest level since the onset of the global financial crisis. This result requires special attention. It turns out that, regardless of the fact that the structure of Polish government non-resident investors has arguably "improved" (become more stable) in recent years, contagion during stress periods still occurs. This is clearly evident in the crisis periods, triggered by events that changed market perception of risk (credit risk in particular), as well as in the periods which signal a shift in the monetary policy stance of globally important countries, which may be followed by hot money portfolio outflows. From the policy viewpoint it underscores the importance of proper communication with the market to avoid policy-induced shocks that translate into abrupt changes in prices.

Dynamic propensity to crash together between Polish and core markets' 10Y yields

Figure 3



Notes: The figure plots upper tail dependence coefficients between 10Y Polish government bond yields and German bund yields, as well as between 10Y Polish government bond yields and US Treasury yields from dynamic SJC copulas (purple lines). For comparison are added upper TDCs from the estimation of unconditional SJC copulas in subsamples (green "step" lines, compare Figure 2, right-hand panel).

5. Conclusions

Following sizeable liquidity injections undertaken by the major central banks since the onset of global financial crisis, the emerging debt markets have experienced large portfolio inflows. The inflows to Poland were significant compared to those received by other EMEs. In this study we argue that the stability perspective merits particular attention as possible consequences resulting from a disorderly outflow of a large base of foreign portfolio capital may be very damaging to the local economy. We employ the copula method which allows us to account for the dependence between financial assets better than the traditional Pearson correlation. More specifically, we use tail dependence coefficients, derived from the copulas, to examine the tendency of two markets to crash together, often interpreted in the literature as contagion, and focus on the pairs of Polish and core market 10-year sovereign bond yields. The results show that in the second subsample (September 2008 onwards) the extreme dependence has declined on average. Specifically, the propensity of the Polish 10-year yields to crash together with core market yields has decreased. We also note that the structure of non-residents investing in Polish

government bonds has changed considerably. Stable investors have increased their share at the expense of speculative capital. Furthermore, the investor base has become visibly more stable. The recent outflows from the debt market beginning in May 2013 were more limited. It transpires that a stable structure of non-residents acted as a stabiliser and reduced extreme dependence on average. Such developments improve financial stability, sparing the country even bigger problems. Capital inflows may thus, under some conditions, turn out to be positive for a country, rather than a danger as often emphasised in the literature. It also underscores the need to efficiently manage the flows.

As always, the authorities should not be led into a false sense of security, as the current state of stability may sow the seeds of a future crisis. Indeed, a closer look at our additional results highlights the facts that there are still periods, often short-lived, during which Polish yields experience significantly more contagion from core yields, and that these periods are most pronounced when global markets come under stress. Specifically, the mid-2013 speculation about the start of QE tapering manifested itself in another large bout of contagion. In this regard, the extreme dependence estimates send a warning signal – to the effect that there is still a possibility of spillovers into a country identified as relatively safe in the region. On the policy front, our results confirm that the central bank needs to communicate carefully with the market to avoid policy-induced shocks that could translate into abrupt changes in the financial markets.

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