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*Milda Burzała**

DID THE CRISIS ON THE INTERBANK MARKET RUN PARALLEL TO THE CRISIS ON THE CAPITAL MARKET? A COSPECTRAL ANALYSIS

1. INTRODUCTION

The effects of the collapse of all financial market segments and of real goods markets outside the United States, i.e. in distant Asian and European countries, show that the financial crisis of 2007–2009 was global in nature. For analysts of the crisis it is important to find out whether or not financial market disturbances occurred simultaneously for different segments of this market. If certain lags are identified, this might be a basis for establishing the direction of capital flows. The research presented in this article deals with the changes that were observed on the interbank market and the capital market.

The situation on the U.S. capital market was represented by the stock market index Dow Jones Industrial Average (DJIA), whereas the situation on the interbank market was represented by the spread between the three-month LIBOR rate and the corresponding OIS rate. This is because the crisis on the interbank market was a crisis of confidence, and spreads represent both credit risk premiums and liquidity premiums on the interbank market (Sengupta & Yu, 2008; Thornton,

* Milda Burzała, Department of Econometrics, Poznań University of Economics, Al. Niepodległości 10, 61-875 Poznań.

2009; Płuciennik et al., 2013). These are therefore a good measure of the fears of a partner's insolvency on the interbank market.

The research hypothesis about the simultaneous occurrence of capital and interbank market disturbances was verified by using cospectral analysis. The transmission of crisis and market contagion concept is defined in the first section. The empirical research methodology adopted for the purpose of this article is presented in the second section. The third section describes the empirical study and provides the criteria for dividing the set of observations into a subset representing the time of crisis and a subset relating to the time of tranquillity. The results of this empirical study are discussed in the fourth section. The article closes with a summary and a list of essential references.

2. TRANSMISSION OF A CRISIS OR MARKET CONTAGION?

The transmission of a crisis should be distinguished from the process of contagion in financial markets. The transmission of a crisis occurs as a result of fundamental links (connections) between markets and usually happens much more slowly than market contagion, which is a very rapid process. Both of these concepts are defined on the World Bank's website (Definitions of Contagion, 2014). The term 'fundamental links' refers to real connections (mainly international trade) as well as financial and political links between markets. Empirical research shows that financial links play a major role in the process of contagion in markets (e.g. Dornbusch, Park & Claessens, 2000; Pericoli & Sbracia, 2003; Dungey et al., 2003). However, the process itself should not be only equated with the effects of financial links because it can also occur on markets that are not financially connected in any significant manner. Contagion effects can be observed as a result of financial shocks, the spread of uncertainty or investors' behaviour which is difficult to predict. The existing financial links do, however, amplify the contagion effect.

A broad definition of contagion, as proposed by the World Bank, is very general and consistent with the classical understanding of the transmission of shocks. According to this definition, contagion is the international transmission of shocks or the general spillover effects between markets. Contagion can occur both during "good" and "bad" times and it is not only associated with crises, but it is more intense in a time of crisis. Under the narrow definition of this concept, contagion is the transmission of shocks to other markets or an interdependence between markets that goes beyond the fundamental links between them and beyond the effects of common shocks. It is usually related to extraordinary events that are explained as being due to herding behaviour among investors and it is treated as comovement on markets. According to a very narrow definition of this term, contagion occurs when cross-market correlations increase significantly in the "time

of crisis" relative to the "time of tranquillity". In this case, it is also assumed that markets will react immediately and, therefore, simultaneous correlations between them are studied, whereas contagion effects are manifested in a phenomenon referred to as correlation breakdown.

It is assumed that if the correlation between certain markets does not increase significantly after a shock, the relationship between those markets is a result of the fundamental links between them (Forbes & Rigobon, 2002).

The basic problem associated with empirically studying contagion effects on the financial market is how to measure these effects (i.e. which method to use). If one assumes that it is shocks going beyond fundamental links that are to be studied, then one should think which model would be best for this purpose. If one decides to use correlation analysis, one should remember that correlation may increase not only as a result of contagion but also because of the interdependencies between markets.

The broad definition of contagion that has been provided by the World Bank requires the connections between markets to be identified. The possibilities for constructing a model of this kind largely depend on the extent to which such connections have been identified and on access to long, good quality and comparable time-series data. Because of the extent to which markets are currently interconnected as well as the numerous feedback loops, empirical research focuses on analysing the significance of particular contagion channels. At the same time it is assumed that every research method should control for fundamental links in some way. The concept of market contagion usually refers to the transmission of financial market disturbances within the same segment of this market (the money market, or capital or foreign exchange markets).

Investors' herding behaviour, i.e. orientation towards the reactions of others, as well as panic and self-fulfilling prophecy are usually mentioned among the causes of contagion in markets. It is emphasised in the literature that such behaviour among investors is, to a large extent, caused by information asymmetry.

On the interbank market, information, especially its completeness and symmetry, constitutes an important factor in maintaining liquidity. However, since information about a partner's credibility is expensive, banks usually use information that is publicly available (for example, assessments made by credit rating agencies), and interbank lending is largely based on mutual trust. The uncertainty that results from having incomplete and asymmetric information can lead some banks to withdraw from the market because the costs are too high. During the last crisis, banks refrained from entering into transactions on the interbank market and they faced greater liquidity shocks as a result of growing uncertainty about the amount of "bad assets" on banks' balance sheets. Those banks had to rely on their own funds and keep additional reserves to maintain liquidity, resulting in other banks having difficulty obtaining the necessary capital

(Heider, Hoerova & Holthausen, 2009). Here, the phenomenon of moral hazard also applies to banks with a strong market position, which may refrain from lending in order to generate additional profits. This, in turn, often causes other banks to sell off their assets at a reduced price (Allen, Carletti & Gale, 2009).

The capital market is closely related to the interbank market. Banks act as intermediaries between buyers and sellers of securities on the stock exchange. They themselves can also purchase stocks and shares in investment funds. However, their activity in this regard is restricted by the capital concentration limit (Szelągowska, 2013)[1], which applies for example, to holdings in banks, financial institutions and insurance companies. Therefore, banks' investment portfolios (in particular, banking corporations' portfolios) contain shares in investment funds and trust funds, investment certificates, shares in subsidiaries, and sometimes also stocks and shares in industrial companies as well as government debt securities (Pyka, 2012). This means that banks have a great impact on capital market transactions and, what is more, they themselves issue shares. The valuation of assets in the banking sector depends on banks' financial condition, and this sector plays a significant role in stock market capitalisation.

During the last financial crisis, banks held the vast majority of toxic collateralised debt obligations (CDO). Since subprime lending was becoming increasingly unprofitable, the demand for asset-backed commercial papers (ABCP) which were issued by securitisation funds and which were used to purchase debt declined. This forced banks to open lines of credit for securitisation funds and bring some CDOs onto their balance sheets, which significantly increased the demand for liquidity (Sławiński, 2007). In a situation like this one is compelled one to sell off other securities.

The financial crisis in 2007–2008 resulted from shocks related to a lack of liquidity on the interbank market. The strength of those shocks caused a significant growth of the system risk associated with integration and globalization of financial markets. Transmission mechanisms were started directly through banks interdependencies and indirectly through asset prices, hence the relation of interbank market and capital market should be considered as indirect.

Instability in any segment of the financial market, including the interbank market, can have negative consequences for the equity market. During the last financial crisis, a lack of confidence in the interbank market was reflected in rising interest rates on loans, and an increase of uncertainty on the capital market was manifested in a significant decline in stock market indices.

This empirical study attempted to answer the question of whether the financial crisis on the interbank market ran parallel to the crisis on the capital market and

[1] In Poland a bank may not invest more than 10% of its own funds in shares in one entity or entities that are related by capital or management (Polish Financial Supervision Authority 2013).

whether the relationship between the crises on both markets resulted from the interdependencies between those markets or from contagion, or whether it should be analysed in terms of the transmission of a crisis.

3. FUNDAMENTALS OF COSPECTRAL ANALYSIS

Spectral and cospectral analysis is frequency domain analysis, does not involve higher than second moments and makes it possible to study details that are invisible when carrying out time domain analysis. This analysis is thus an important complement to results obtained by using other research methods. There is currently an extensive body of literature on the topic of spectral and cospectral analysis (Granger & Hatanaka, 1964; Priestley, 1981; Talaga & Zieliński, 1986; Hamilton, 1994; Koopmans 1995; Storch & Zwiers, 2004), so this section only presents those fragments of spectral and cospectral analysis which were used in the empirical research.

Mutual spectral analysis makes it possible to study the relationship between particular frequencies within two time series. Here the so-called cross-spectrum is the basic value, which can be written in complex form based on de Moivre's theorem:

$$S_{yx}(\omega) = \frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty} K_{yx}(\tau)\cos\omega\tau - i\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty} K_{yx}(\tau)\sin\omega\tau = \\ = c_{yx}(\omega) - iq_{yx}(\omega) \quad \text{dla } \omega \in [-\pi, \pi], \tag{1}$$

where:
$K_{yx}(\tau)$ denotes a covariance of the two stochastic processes: Y_t and X_t,
$c_{yx}(\omega)$ denotes the co-spectrum (the real part of the cross-spectrum),
$q_{yx}(\omega)$ denotes the quad-spectrum (the imaginary part of the cross-spectrum).

It is assumed that these processes meet the assumptions of stationarity (with an expected value of zero) and ergodicity. The co-spectrum represents a covariance between the components of stochastic processes X_t and Y_t having the same phase, whereas the quad-spectrum measures the covariance of components that are shifted in the phase by $\pi/2$.

Cospectral analysis involves certain characteristics being derived, based on which two processes are compared.

The phase shift (which is measured in radians) identifies leads (or lags) of variable X with respect to variable Y (a positive value indicates a lead; a negative value indicates a lag) for frequency ω:

$$\phi_{yx}(\omega) = arctg\left(\frac{q_{yx}(\omega)}{c_{yx}(\omega)}\right) \quad dla\ \omega \in [-\pi;\pi] \tag{2}$$

The coherence coefficient is a measure of fit (R^2) in the regression of variable Y with respect to variable X for frequency ω:

$$K_{yx}^2(\omega) = \frac{c_{yx}(\omega)^2 + q_{yx}(\omega)^2}{S_x(\omega) \cdot S_y(\omega)}, \qquad 0 \le K_{yx}^2(\omega) \le 1 \; dla \; \omega \in [-\pi; \pi], \tag{3}$$

where $S_x(\omega)$, $S_y(\omega)$ denote the spectra of processes X_t and Y_t, respectively.

Croux, Forni and Reichlin's (1999) correlation coefficient is:

$$\rho_{yx}(\omega) = \frac{c_{yx}(\omega)}{\sqrt{S_y(\omega) S_x(\omega)}}, \qquad -1 \le \rho_{yx}(\omega) \le 1 \;\; dla \; \omega \in [-\pi; \pi]. \tag{4}$$

The following formula represents the coefficient of correlation between variables X and Y within frequency band ω_1 for two frequencies, ω_2 and $[\omega_1, \omega_2]$:

$$\rho_{yx}([\omega_1, \omega_2]) = \frac{\int_{\omega_1}^{\omega_2} c_{yx}(\omega) d\omega}{\sqrt{\int_{\omega_1}^{\omega_2} S_y(\omega) d\omega \int_{\omega_1}^{\omega_2} S_x(\omega) d\omega}}. \tag{5}$$

For $\omega_1=0$ and $\omega_2=\pi$ (the whole frequency domain) $\rho_{yx}([0,\pi])=\rho_{xy}$ in the time domain.

The given characteristics are estimated based on the smoothed values of the spectrum and cross-spectrum (Hamilton 1994; Storch & Zwiers 2004)[2].

4. THE EMPIRICAL RESEARCH

In empirical research related to cospectral analysis, one only considers those leads or lags at a given frequency which are associated with a high value of the coherence coefficient (for strongly correlated frequency components).It is therefore important that boundary values or confidence intervals should be established for coherence coefficients and the phase shift.

The following steps were included in the experimental design with regard to two samples from the time of tranquillity and the time of crisis:

A. Determining boundary values in order to assess the significance of coherence coefficients (Storch & Zwiers, 2004). It was assumed that insignificant relations were due to the impact of random factors.

[2] The estimator of the spectrum of a stochastic process is not a consistent estimator, which means that its variance does not decrease as the sample size increases. In order to reduce variance the periodogram is smoothed, but this is done at the expense of losing the estimator's unbiasedness.

B. Checking the significance of the lead (lag) of the appropriate harmonics for frequencies related to significant coherence coefficients. The confidence intervals proposed by Goldman in 1957 (cited after Koopmans, 1995) were used for this purpose. The frequencies were thus divided into those that were associated with the lagged (leading) response of the studied variable and those that reflected simultaneous changes, i.e. comovements.

C. Analysing covariance and correlation for simultaneous, lagged and leading fluctuations.

D. Decomposing the variance of rates of return on a given index Y which is explained by changes in rates of return on another index X:
where:

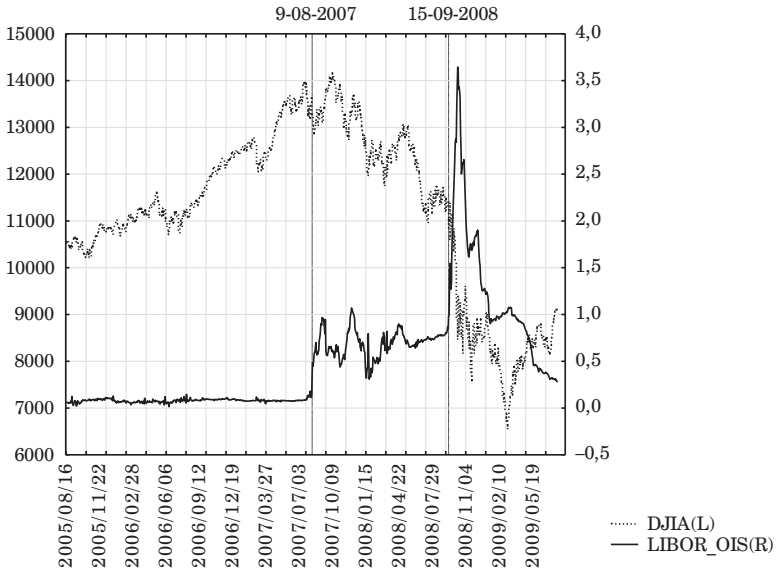
– explained variance for lagged (leading) reactions,
– explained variance for simultaneous reactions,
– unexplained variance resulting from random factors.

For the purpose of theoretical analysis, it is reasonable to assume that simultaneous changes in rates of return occur as a result of the interdependence between markets (financial connections) or in response to events taking place in so-called third-country markets. Lagged reactions can be the result of contagion spreading to the market studied from another market (Burzała, 2014). Depending analysis for different segments of the financial market can form a basis for studying causality or the direction in which a crisis spreads and financial shocks are propagated. However, it is difficult to determine which changes are leading and which are lagged with respect to the studied changes in rates of return under conditions of their high volatility. This is why current research methods focus on analysing simultaneous changes, i.e. comovements, which means that it has been assumed that financial markets react immediately to financial shocks[3]. Figure 1, which presents the values of the Dow Jones Industrial Average index and the spread between the three-month LIBOR rate and the corresponding OIS rate, also indicates that this assumption is valid. Instability and an increase in the LIBOR-OIS spread could be observed starting from August 2007, which was when the French BNP Paribas announced information about difficulties associated with evaluating assets. It was exactly on 9 August 2007 that this bank suspended payments from three funds investing in the market of bonds secured by subprime mortgages. However, the spread increased most rapidly after the collapse of Lehman Brothers in September 2008. The chart presented here suggests that the changes on both markets occurred simultaneously – an increase in the spread is connected with a decline in the index.

[3] Cf., among others, the Granger causality tests for expected values (1969) as well as causality in variance and causality in risk tests (Cheung & Ng 1996; Caporale, Pittis & Spagnolo 2002; Hong, Liu & Wang 2009).

Cospectral analysis makes it possible to compare the structures of time series, identify potential differences and differentiate between simultaneous and lagged (leading) changes within a given time series.

Figure 1. The Dow Jones Industrial Average and the LIBOR-OIS spread for the dollar market (16 August 2005–31 August 2009)



Source: based on data obtained from the Reuters and Stooq database.

The information about BNP Paribas's difficulties served as a basis for dividing the set of observations into two subsets (the time of tranquillity and the time of crisis). Among those who consider the day this information was announced to be the date that marks the beginning of the crisis were Baba, Packer and Nagano (2008) as well as Taylor and Williams (2009). Thus, the samples from the time of tranquillity and the time of crisis on financial markets contained the same number of observations (517) for both these periods.

Since the original time series were non-stationary, the study was conducted based on continuously compounded rates of return on the stock market index and the first changes in spread levels.

5. RESEARCH RESULTS

The smoothed values of the spectrum and cross-spectrum were estimated by using the Bartlett weights with the window's width $M = 31$[4]. In tests related to spectral and cospectral analysis the number of degrees of freedom is replaced with the so-called equivalent number of degrees of freedom (EDF). For the Bartlett weights this number is 3T/M (Koopmans, 1995). For T = 518 observations (in the time of crisis and the time of tranquillity) the equivalent number of degrees of freedom that is used in tests is 50.

5.1. Significant coherence coefficients and the phase shift

The significance of coherence coefficients was assessed at a significance level of α=0.01. This means that coefficients lower than 0.174 were regarded as referring to insignificant relations that reflected the effects of random factors. The charts in Figure 2 present coherence coefficients.

As expected, the structure of relations between the stochastic processes analysed changed in the time of crisis. During the conventionally identified tranquillity period, significant relationships between rates of return on the stock market index and the first changes in spread levels were only observed within a narrow fluctuation band which lasted for less than three days. Significant relationships become stronger both for high- and lower-frequency fluctuations during the period of crisis. Lower frequencies correspond to medium-term fluctuations (10–16 days), which here lead to a considerable increase in the spreads analysed on the interbank market and a decline in the index on the capital market. During the crisis, significant relationships for high frequencies refer to short-term fluctuations which last for up to five days.

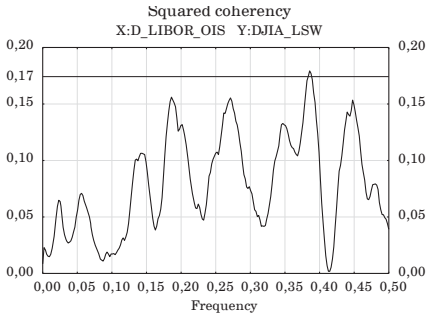
The significance of the phase shift was assessed at the same significance level, i.e. α=0.01. For comparison, the relevant charts presenting frequencies that are significant with respect to both the coherence coefficient and the phase shift (the grey, shaded area) are also shown in Figure 2 below the respective coherence coefficients.

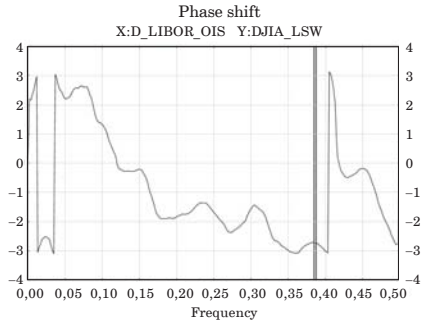
At the beginning of this study it was assumed that all fluctuations which were significant with respect to the coherence coefficient and which did not exhibit a significant phase shift referred to comovements in the markets. However, for the time series analysed, no significant relationships were found with regard to these fluctuations.

[4] The researcher decides on the width of the window. The wider the window, the smoother the function and the smaller the estimator's variance; the narrower the window, the larger the estimator's variance but also the smaller the estimator's bias.

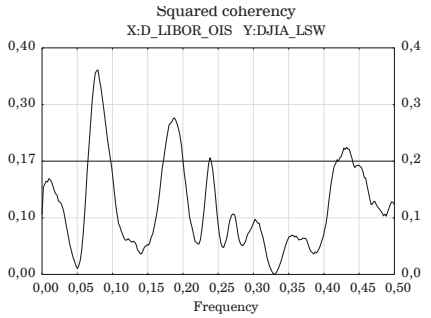
Figure 2. Significant coherence coefficients and phase shifts in the time of crisis

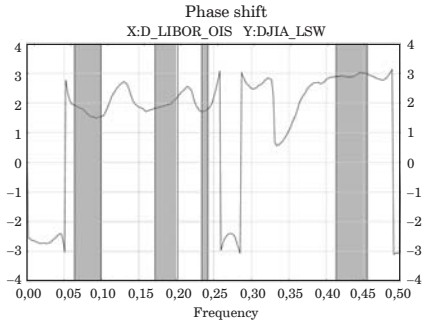
Time of tranquillity
16 August 2005–8 August 2007





Time of crisis
9 August 2007–31 August 2009





Source:own work.

Given the assumptions that are presented in the first section, the lack of significant comovements on financial markets both in the time of tranquillity and in the time of crisis shows that there are no direct interdependencies between these markets. Both leading and lagged changes on these markets can only indicate the occurrence of contagion effects. These reactions could not have been intensified due to the transmission of a crisis resulting from the strengthened interdependencies between these markets if the empirical study did not confirm that such interdependencies existed.

Significant change in the relationships between fluctuations was observed with regard to the phase shift. In the time of tranquillity a narrow band of significant fluctuations was related to a significant negative phase shift, which indicates that the capital market's reaction was leading with respect to changes on the interbank market (about one day). In the time of crisis a positive phase shift was significant, which shows that the reaction of the spread in the interbank market was leading

with respect to changes on the capital market. A significant lead of changes that occurred in the interbank market was not longer than two days within a short-term fluctuation band (lasting for up to one week), and it was slightly longer within a medium-term fluctuation band (from two to five days).

One should remember that this is frequency domain analysis and the rates of return that are observed in the time domain result from a combination of many harmonic components (as many as 258 in the studies). Therefore, one should not identify the phase shift between two harmonics with the market's reaction that is observed in the time domain. However, phase shifts between many harmonic components have a significant influence on the market's lagged reaction. An attempt at assessing the impact of lagged fluctuations is presented in the next section of this chapter.

5.2. Analysis of connections between the markets studied

It is worthwhile beginning this analysis by calculating the covariance and correlation coefficients together for all frequencies, which corresponds to time domain analysis. Negative covariances and correlations are the result of the diverse behaviour of the analysed time series during turmoil on the financial market. The results are presented in Table 1. They indicate that there was an insignificant increase in negative correlation for the whole frequency range[5]. The assessment of a change in the connections between markets which is made based on Pearson's correlation coefficient is not without its drawbacks[6]. Therefore, in the book titled *Selected Methods of Studying Contagion Effects in Capital Markets* (2014) the author proposes that weights should be created so that the results obtained can also be applied in studies that are carried out using different research methods. The proportion of comovements will show the strength of the interdependencies between the markets, whereas the proportion of lagged or leading changes will indicate the strength of contagion effects.

In an analysis of two markets, an adequate weight describing the importance of correlation (covariance) with regard to lagged (leading) changes would take the following form:

$$w^{K(L)} = \frac{\left|m^{K(L)}\right|}{\left|m^{K(L)}\right| + \left|m^{K(R)}\right|}, \tag{6}$$

5 Fisher's transformation was used to assess the change in the correlation coefficient.

6 The classical correlation coefficient is susceptible to outliers. One cannot correctly define the correlation coefficient based on this measure if the variance of variables is infinite. Moreover, this measure is not invariant to monotonic transformations (the correlation between a pair of variables is different from the correlation between the logarithms of those variables). Forbes and Rigobon (2002) point out that Pearson's correlation coefficient is a positive function of volatility and can result in overestimation of the relations between rates of return during a crisis.

where $m^{K(L)}$ denotes a measure of dependence (correlation or covariance) which results from significant fluctuations in the area of lagged (leading) changes, whereas $m^{K(R)}$ denotes a measure of insignificant interdependencies between the markets[7]. A similar method for constructing weights can be proposed for variance which is observed for different fluctuation bands. Table 1 presents weights that were constructed based on formula (6).

It is worth paying attention to the high negative correlation between fluctuations that were shifted in the phase during the tranquillity period (–0.386). This value results from low covariance and relatively small standard deviations. Consequently, a weight with a high value (0.86) is obtained within a very narrow fluctuation band. For the same reason, correlations with regard to lagged and insignificant changes in the time of crisis show low variability. Covariance is therefore a better measure of such relationships because it allows weights to be obtained reflecting the influence of fluctuations within a given band on the value of the measurement within the time domain. If one assumes that the value of covariance is the basis for this analysis, one can conclude that the covariance of the processes studied on the capital market and the interbank market in the time of crisis was small and was mainly the result of random factors, which is visible in a weight value of 0.74 for insignificant relationships. Thus, this means that only one fourth of the reactions on the capital market occurred as a result of changes that took place on the interbank market (as regards the estimated covariance).

This analysis of covariance deals with the relations between rates of return on stock market indices and increases in the LIBOR-OIS spread. A similar analysis can be carried out with regard to variance. Figure 3 presents the importance of variance resulting from insignificant relationships and lagged changes on the capital market (and leading changes in the interbank market) in the time of crisis. In this regard the present study confirms the conclusions that were drawn from the analysis of covariance (considerable importance of variance resulting from insignificant relationships).

The results that are presented in the paper show that the contagion effects which were observed on the capital market and which resulted from increased uncertainty on the interbank market were small but significant. The theories mentioned in the literature which explain financial crises relate to endogenous shocks which are predictable and which are related to a growing economic imbalance and usually manifested in the behaviour of specific macroeconomic indicators[8].

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7 The structure of the formula for calculating weights depends on the number of bands that have been identified. Generally speaking, the denominator can be expanded by including measures of dependence for lagged, leading, and simultaneous fluctuations (cf. Burzała 2014).

8 In the literature, three mechanisms that explain the occurrence of financial crises are usually mentioned. The first mechanism is connected with Mishkin's research and the theory of asymmetry, the second one with the idea of the financial accelerator (loans) and the third with Minsky's financial instability hypothesis.

Table 1. Weights describing the importance of the interdependencies between the markets in different fluctuation bands

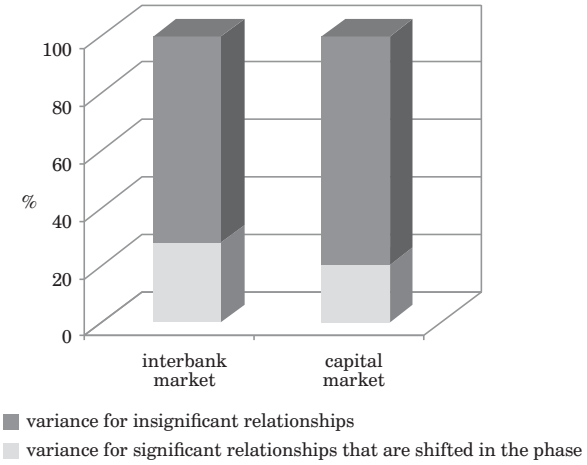
time of tranquillity					Weights			
changes with regard to	Variance		covariance	correlation	variance		covariance	correlation
	X	Y	(Y,X)	(Y,X)	X	Y	(Y,X)	(Y,X)
leading fluctuations on market Y	0.000004	0.006616	–0.000062	–0.386	2%	2%	11%	86%
insignificant fluctuations	0.000187	0.403836	–0.000525	–0.060	98%	98%	89%	14%
fluctuations within the whole frequency range	0.000191	0.410451	–0.000587	–0.066	100%	100%	100%	100%
time of crisis					**Weights**			
changes with regard to	Variance		covariance	correlation	variance		covariance	correlation
	X	Y	(Y,X)	(Y,X)	X	Y	(Y,X)	(Y,X)
lagged fluctuations on market Y	0.001254	0.776	–0.00649	–0.208	28%	20%	26%	54%
insignificant fluctuations	0.003299	3.162	–0.01809	–0.177	72%	80%	74%	46%
fluctuations within the whole frequency range	0.004553	3.938	–0.02458	–0.184	100%	100%	100%	100%

Symbols: Y – rates of return on the DJIA stock market index, X – first increases in the LIBOR-OIS spread.

Source: own calculations

Contemporary financial crises are sudden and they are usually characterised by exogenous shocks which are difficult to predict. However, it is possible to build economic and financial structures that will be strong enough to minimise the losses incurred as a consequence of these crises. The last financial crisis drew attention to the need to introduce many micro- and macro-prudential regulations aimed at improving the stability of the financial system, but a description of those regulations is beyond the scope of this paper.

Figure 3. Importance of variance for different relationships in the time of crisis



Source: own work.

6. SUMMARY

The results of empirical research that are presented in this article indicate that the covariance of the segments of the financial market studied in the U.S. was very low. This means that the capital market only showed a delayed reaction to single impulses coming from the interbank market in relation to certain crisis events. The study did not show significant simultaneous dependencies. The interactions between these markets were "more chaotic" than might be inferred by analysing the charts visually. The results of the study carried out using cospectral analysis, which are presented in this article, cannot be obtained by employing other research methods. This is because an analysis of the structure of the processes studied makes it possible to separately identify changes occurring within different fluctuation bands.

The lack of systematic (direct) links between these markets suggests that further time domain analyses should be carried out using methods that will make it possible to study shocks (such as event studies and probability or volatility models).

In the United States, special financial institutions and capital markets handle financing of investment projects (a market-oriented economy). It is worth verifying the conclusions presented in the article on the European markets, where banks are the main source of short and long-term capital (a bank-oriented economy). Market analysts emphasize that the Euro zone affected financial market structure change in Europe, nevertheless, research can result in very valuable conclusions.

Abstract

For analysts of the crisis it is important to find out whether financial market disturbances occurred simultaneously for different segments of this market. If certain lags are identified, this might form a basis to establish the direction of capital flows. The research hypothesis about the simultaneous occurrence of capital and interbank market disturbances was verified by using cospectral analysis. The results of empirical research that are presented in this article indicate that the covariance of the studied segments of the financial market in the U.S. was very low. This means that the capital market only showed a delayed reaction to single impulses coming from the interbank market in relation to certain crisis events.

Key words: financial crisis, interbank market, capital market, cospectral analysis

References

Allen, F., Carletti, E., Gale, D. (2009): Interbank Market Liquidity and Central Bank Intervention, *Journal of Monetary Economics*, vol. 56, no. 5, 639–652.

Baba, N., Packer, F., Nagano, T. (2008): The spillover of money market turbulence to FX swap and cross-currency swap markets, *BIS Quarterly Review*, March, 73–86.

Burzała, M.M. (2014): *Wybrane metody badania efektów zarażania na rynkach kapitałowych* [*Selected Methods of Studying Contagion Effects in Capital Markets*], Wydawnictwo Naukowe Uniwersytetu Ekonomicznego w Poznaniu, Poznań.

Caporale, G.M., Pittis, N., Spagnolo, N. (2002): Testing for Causality-in-Variance: an Application the East Asian Markets, *International Journal of Finance and Economics*, No. 7/3, 235–245.

Cheung, Y.W., Ng, L.K. (1996): A causality in variance test and its application to financial market prices, Journal of Econometrics, 72, 33–48.

Croux C., Forni M., Reichlin L. (1999): *A Measure of Comovement for Economic Variables: Theory and Empirics*, CEPR Discussion Paper No. 2339, Centre for Economic Policy Research, London.

Definitions of Contagion, 2014, The World Bank, http://econ.worldbank.org/wbsite/external/extdec/extresearch/extprograms/extmacroeco/0,,contentMDK:20889756~pagePK:64168182~piPK:64168060~theSitePK:477872,00.html [24.05.2014].

Dornbusch, R.S., Park, Y.C., Claessens, S. (2000): Contagion: Understanding How It Spreads, *The World Bank Research Observer*, vol. 15, no. 2, s. 177–197.

Dungey, M., Tambakis, D. (2003): International Financial Contagion: What do we know?, Working Paper, no. 9, Cambridge Endowment for Research in Finance, Judge Institute of Management.

Forbes, K., Rigobon, R. (2002): No Contagion, Only Interdependence: Measuring Stock Market Comovements, *The Journal of Finance*, No. 57/5, 2223–2261.

Granger, C.W.J. (1969): Causal Relations by Econometric Models and Cross-spectral Methods, *Econometrica*, No. 37/3, 424–438.

Granger, C.W.J., Hatanaka M. (1964): *Spectral Analysis of Economic Time Series*, Princeton University Press.

Granger, C.W.J. (1969): Causal Relations by Econometric Models and Cross-spectral Methods, *Econometrica*, vol. 37, no. 3, 424–438.

Hamilton, J.D. (1994): *Time series analysis* (Vol. 2). Princeton: Princeton University Press.

Heider, F., Hoerova, M., Holthausen, C. (2009): Liquidity Hoarding and Interbank Markets Spreads: The Role of Counterparty Risk, *ECB Working Paper Series*, vol. 1126.

Hong, Y., Liu, Y., Wang, S. (2009): Granger Causality in Risk and Detection of Extreme Risk Spillover Between Financial Markets, *Journal of Econometrics*, No. 150/2, 271–287.

Koopmans, L.H. (1995): *Probability and Mathematical Statistics: The Spectra Analysis of Time Series*, Academic Press, Burlington.

Pericoli, M., Sbracia, M. (2003): A Primer on Financial Contagion, *Journal of Economic Surveys, Wiley Blackwell*, vol. 17, no. 4, 571–608.

Płuciennik, P., Kliber, A., Kliber, P., Paluszak, G., Piwnicka, M. (2013): Wpływ światowego kryzysu gospodarczego 2007–2009 na rynek międzybankowy w Polsce [The impact of the global economic crisis 2007–2009 on the interbank market in Poland], *Materiały i Studia*, Zeszyt 288, NBP, Warszawa.

Priestley, M. (1981): *Spectral Analysis and Time Series*, London: Academic Press.

Pyka, I. (2012): *Rynkowe instrumenty finansowe w alokacji kapitału bankowego* [*Market-based instruments in the allocation of bank capital*], Dyfin, Warszawa.

Sengupta, R., Yu, M.T. (2008): The LIBOR-OIS Spread as a Summary Indicator, *Economic Synopses*, No. 25, Federal Reserve Bank of St. Louis.

Sławiński, A. (2007): Przyczyny i konsekwencje kryzysu na rynku papierów wartościowych emitowanych przez fundusze sekurytyzacyjne [Causes and consequences of the crisis on the market for securities issued by securitization funds], *Bank i Kredyt*, vol. 38, no. 8–9, NBP, Warszawa.

Storch, H., Zwiers, F.W. (2004): *Statistical Analysis In Climate Research*, Cambridge University Press.

Szelągowska, A. (2013): *Inwestycje zagraniczne w sektorze bankowym. Implikacje dla rynku kapitałowego* [*Foreign investments in the banking sector. Implications for the capital market*], www.mikroekonomia.net/system/publication_files/1112/original/23.pdf [2.11.2013].

Talaga, L., Zieliński, Z. (1986): *Analiza spektralna w modelowaniu ekonometrycznym* [*Spectral Analysis in Econometric Modelling*], PWN, Warszawa.

Taylor, J.B., Williams, J.C. (2009): A black swan in the money market, *American Economic Journal:Macroeconomics*, 1(1), 58–83.

Thorton, D.L. (2009): What the Libor-OIS Spread Says, *Economic Synopses*, No. 24, Federal Reserve Bank of St. Louis.