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THE INFLUENCE OF SPATIAL AND ECONOMIC DISTANCE ON CHANGES IN THE RELATIONSHIPS BETWEEN EUROPEAN STOCK MARKETS DURING THE CRISIS OF 2007–2009

Abstract. The influence of the spatial relation on the stock market is becoming more frequently the subject of a discussion. Efforts to pinpoint the relation between the distance and the investors choices are relevant to both the intra- and intermarket connections. With the latter one, spatial dependencies may function as a shock transmission channel, resulting with the contagion effect.

The object of this paper is to present the results of the research on the influence of spatial and economic distance on the correlation of selected European stock markets during the 2007–2009 crisis period. In order to verify the hypothesis regarding the influence of the spatial relations on the stock market correlation DCC GARCH model was used among with spatial analysis tools.

Keywords: DCC GARCH, Euclidean distance, crisis period, stock market

1. INTRODUCTION

The global stock markets declining in the middle of 2007 proved that signals from the United States influenced investors' behavior. The stock exchanges' falls were the first indication of the coming crisis, which shortly spread over the other part of the economy. The country-specific crisis propagation mechanism could be explained by analyzing the interrelated elements of the financial markets and the real sector of country's economy, but explaining the reasons why the particular space scheme occurred is much more difficult, especially if the negative shock transmission in a geographic space is observed. The problems with explaining these relations arise from their number occurring between the countries and the significant role of investors' behavior and beliefs.

The international shock spillover and the possible declines in the particular countries are caused by the integration with international markets. This means that the speed of globalization determines the frequency at which international

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and global markets decline, as some researchers believe[1]. The relationship between the crisis spillover sources and the globalization process speak for considering the related spatial interaction. Geography and economic distance, marginalized in the analysis of the relationship between financial markets, became a more frequent subject of discussions during the 2007–2009 crisis[2]. Despite the liberalization of money flows and technological progress that eliminate the barriers to trade, the importance of spatial conditions for the development of financial markets (including stock markets) and their functioning has been proved by successive studies (e.g. those dealing with the influence of the metropolisation process on the location of financial centers)[3].

The importance of geography and economic distance as revealed by the relationships between the main stock indexes should be analyzed following two different lines:
–   geography of finance and money,
–   behavioral finance.

The first one concerns the location of international financial centers and the directions of capital flows. The speed of the spillover process and the global extent of the shock are determined by the level of concentration of transactions in the strategic centers that operate within a liberal environment. As a result, the problems of one international financial institution can play an important role, triggering declines in other centers. One feature of the financial centers is their ability to form clusters of specific institutions. They are also capable of concentrating the financial infrastructure. Their last feature can be seen in the consolidation of stock exchanges that results in an international platform creating trade. The location of a regional stock exchange platform follows from the financial centers' impacts. One example can be the Scandinavian group OMX or the stock exchange alliance Euronext. Both these platforms concentrate stock exchanges located within the main European financial centers. The stock exchange platform is not only more efficient and more attractive to investors, but it is also characterized by easier shock transmission within it.

The importance of geography and economic proximity in behavioral finance arises from the way space affects the behavior of specific investors. Coval and Moskowitz[4] proved that the institutional investors' decisions are shaped by the issuer's geographical location. The studies by Grinblatt, Keloharju and Huber-

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[1] Schmukler S.L., Zoido P., [2003], *Financial Globalization, Crises, and Contagion*, [in:] *Progress in Economics Research*, Special Issue on International Macroeconomics.

[2] French S., Leyshon A., Thrift N., [2009], *A Very Geographical Crisis: the Making and Breaking of the 2007–2008 Financial Crisis*, Cambridge Journal of Regions, Economy and Society, pp. 287–302.

[3] Huriot J.M., Thisse J.F., [2000], *Economics of cities: theoretical perspectives*, Cambridge University Press, pp.416–417.

[4] Coval, J.D., Moskowitz, T.J., [2001], *The geography of investment: informed trading and asset prices*, Journal of Political Economy, pp. 811–841.

man offered similar findings on private investors[5]. The differences in the degree of assets correlation depends on the geographical area where the issuers are situated. This provides the grounds for stating that stock prices are susceptible to geographical segmentation (the geographical segmentation view). The company's position determining the relationships between its assets or, speaking more broadly, the location of a country shaping the values of stock indexes are extremely important for the ability to quantify the risk that a decline will spread. In this case, the existence of spatial dependencies would mean that a negative shock in the geographically close countries would be stronger not only for the high level of economic relations, but also because of the geographical proximity of the markets perceived by investors.

This paper aims to test the hypothesis about the geographical and economic distance influencing the relationships between stock exchanges in Europe. The process applied to identify interactions can be treated as a first step in the discussion about the economic and geographical space connection with the spillover effect produced by the 2007–2009 crisis. The analysis of stock exchanges interaction builds on behavioral finance theory, geography of finance as well as money-related studies. On the one hand, the following analysis gives some background information about the financial centers' importance in shock transmission during crisis. One the other hand, the analysis highlights investors' behavior and its determinants.

2.   METHODS

The existence of a relationship between stock markets' spatial and economic proximity has been verified by conditional correlation in the DCC GARCH model. Because the building of a conditional heteroskedasticity model should be preceded by the estimation of a mean equation, a vector autoregression model (VAR) with Forbes and Rigobon (FR) correction was employed[6]. The correction made it possible to account for an increase in variance during the crisis. This allowed avoiding the situation where the relationships between the stock markets represented by the main stock indexes were simulated by the high level of variance. The adjusted VAR model has the following form:

$$\left(\frac{\mathbf{y}_{(n)t}}{\boldsymbol{\sigma}_{(n)t_s}} \right) = \mathbf{A}_0 \mathbf{C}_t + \sum_{p=1}^{P} \mathbf{A}_p \left(\frac{\mathbf{y}_{(n)t-p}}{\boldsymbol{\sigma}_{(n)t_s}} \right) + \mathbf{A}_q \left(\frac{\mathbf{y}_{(n)t}}{\boldsymbol{\sigma}_{(n)t_s}} \right) \mathbf{D}_{(n)t_s} + \boldsymbol{\varepsilon}_{(n)t} \tag{1}$$

$$\boldsymbol{\varepsilon}_{(n)t} \sim NID(0, \mathbf{H}_t),$$

[5] Grinblatt, M., Keloharju, M., [2001], *How distance, language, and culture influence stockholdings and trades,* Journal of Finance, pp. 1053–1073.
[6] Dungey M., Fry R., González-Hermosillo B., Martin V., [2004], *Empirical Modeling of Contagion: A Review of Methodologie*s, IMF Working Paper, pp.11–12.

where:

$\mathbf{y}_{(n)t}$ - a vector of logarithmic returns from n European stock indexes in t,

$\mathbf{\sigma}_{(n)t_s}$ - a vector of standard deviations of returns from stock indexes in a stable period t_s,

$\mathbf{A}_0$ - a matrix of the model's deterministic parameters,

$\mathbf{A}_p, \mathbf{A}_q$ - the matrixes of parameters for lag for p variables and exogenous variables,

$\mathbf{D}_{(n)t_s}$ - a vector of the dummy variables being 0 for the stable period and 1 for a stock exchange under crisis,

$\mathbf{C}_t$ - a vector of the model's constant terms.

In addition to introducing variables that represent the situation on the European stock exchanges, the model was extended by using a mechanism for identifying changes in the interaction of stock indexes during crisis. To this end, the FR test for a contagion effect was applied. Due to the universality of the method based on the analysis, the study can successfully use growing interaction between the variables in specific periods of time. The concept of the test involves the identification of extra relationships that are specific to and observable only in the time of crisis. The existence of connections that are important for shock transmission under destabilization arises from the significance of the exogenous variables' parameters. A significant value of the matrix $\mathbf{A}_q$ elements informs about shock transmission taking place between the markets and shows how the impulse is propagated.

Before the crisis-specific variables can be used, the stock indexes' break points should be identified. In this paper, the structural breaks were identified with a Zivot-Andrews test. It is one of the tests for variable stationarity that are used when there is a suspicion that the data structure has a break point. As well as confirming stationarity, the Zivot-Andrews test also allows identifying the time when a break occurred in the process trend.

The residuals provided by the VAR model estimation were used to construct the DCC GARCH model. The negative influence of autocorrelation and conditional heteroskedasticity in the VAR was reduced by the heteroskedasticity and autocorrelation consistent (HAC) estimation of the covariance matrix of the coefficient[7]. The ARCH effect in the VAR model residuals spoke in favor of using the conditional heteroskedasticity model. The DCC GARCH model estimated with MLE had the following form:

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[7] The alternative is an one step estimation of the whole model (VAR-DCC GARCH) using quasi-maximum likelihood estimation (QMLE).

$$\mathbf{H}_t = \mathbf{D}_t \mathbf{R}_t \mathbf{D}_t$$
$$\mathbf{R}_t = \mathbf{Q}_t^{*-1} \mathbf{Q}_t \mathbf{Q}_t^{*-1}$$
$$\mathbf{Q}_t = (1 - \sum_{i=1}^{Q} \alpha_i - \sum_{j=1}^{P} \beta_j)\mathbf{S} + \sum_{i=1}^{Q} \alpha_i(\mathbf{z}_{t-i}\mathbf{z}_{t-i}^{'}) + \sum_{j=1}^{P} \beta_j \mathbf{Q}_{t-j}$$
(2)

where:

$\mathbf{R}_t$ - the matrix of time-varying conditional correlation coefficients,

$\mathbf{S}$ - the unconditional covariance $\mathbf{z}_t$ matrix,

$\mathbf{Q}_t^*$ - the diagonal matrix whose elements are square roots of the diagonal elements of the matrix $\mathbf{Q}_t$.

The estimation of the DCC GARCH model proposed by R. Engle produced a matrix of conditional correlation coefficients:

$$\mathbf{R}_t = \begin{bmatrix} 1 & \rho_{12,t} & \cdots & \rho_{1j,t} \\ \rho_{21,t} & \ddots & & \rho_{2j,t} \\ \vdots & & \ddots & \vdots \\ \rho_{i1,t} & \rho_{i2,t} & \cdots & 1 \end{bmatrix},$$
(3)

where:

$\rho_{ij,t} = \dfrac{h_{ij,t}}{\sqrt{h_{ii,t}}\sqrt{h_{jj,t}}}$ - the conditional correlation coefficient between the stock indexes i and j returns in t,

$h_{ij,t}$ -the conditional covariance of the process,

$h_{ii,t}$ - the conditional variance of the returns from the stock index i in t.

The influence of the economic distance on the level of relationships between European stock exchanges was proved by economic distance matrix used. To each element of the matrix $\mathbf{R}_t$ an pertinent element of the economic distance matrix was assigned:

$$\mathbf{W}_e = \begin{bmatrix} 0 & d_{12} & \cdots & d_{1j} \\ d_{21} & \ddots & & d_{2j} \\ \vdots & & \ddots & \vdots \\ d_{i1} & d_{i2} & \cdots & 0 \end{bmatrix},$$
(4)

where:

$\bar{d}_{ij} = 1/T \times \sum_{t=1}^{T}\sqrt{\sum_{k=1}^{P}(x_{ik,t} - x_{jk,t})^2}$ - the mean Euclidean distance between stock exchanges i and j in the period from 2005 to 2008.

As the measure of the economic distance was used GDP *per capita* and trade balance of country. These macroeconomic categories reflected differences in the economic situation between countries. More importantly, the Euclidean distance calculated using GDP *per capita* and the current account balance was more efficient in capturing the differences between the conditional correlation coefficients than the other macroeconomic variables. The measures described the most marked similarities with the values of conditional correlation.

The conditional correlation coefficients obtained from the DCC GARCH model were compared with the element of the binary matrix of neighborhood relations between countries where stock exchanges are located. The neighborhood matrix was adopted as a measure of the geographical distance between markets. The elements of this matrix take 1 for stock exchanges located in the neighboring countries or 0 when the countries do not have the same border.

Thus, the information about the relationships between changes in stock market indexes and in the economic and geographical distance is obtained. The information about these relationships is important for verifying the hypothesis about the connections between distance and the level of stock markets' correlation.

3.   DATA

The study used data on stock exchanges in 32 European countries. The situation of the stock markets is represented by the log return (continuously compounded return) from the main stock markets indexes calculated as:

$$R_t = \ln P_{t+1} - \ln P_t,$$ (5)

where:

R_t - a rate of return at the time t,

P_t - the closing price of the stock market index at the time t.

The frequency of the data used in the study was daily. The list of the indexes used to describe the changing situation of the stock exchanges is presented in the table 1.

The study was used data on Gross Domestic Product (GDP) *per capita* and the current account balance (in US dollars). The data for the period 2005–2008 were obtained from Eurostat and International Monetary Fund[8].

The VAR and DCC GARCH models were estimated using procedures derived from MFE Toolbox and UCSD Toolbox written by K. Sheppard in Matlab[9]. Besides, the Zivot-Andrews test procedure written in STATA was used[10]. The Geoda software package was used to visualize the results on the maps.

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[8] http://www.imf.org, 01.05.2010.
[9] http://www.kevinsheppard.net/wiki 01.05.2010.

Tab. 1. The main European stock markets indexes

COUNTRY	STOCK MARKET INDEX	COUNTRY	STOCK MARKET INDEX
AUSTRIA	ATX	LATVIA	OMXR
BELGIUM	BEL 20	MALTA	MSE
BULGARIA	SOFIX	GERMANY	DAX
CROATIA	CROBEX	NORWAY	OSE
CYPRUS	CYSE 20	POLAND	WIG
CZECH REPUBLIC	PX 50	PORTUGAL	PSI 20
DENMARK	OMX 20	RUSSIA	RTS
ESTONIA	OMXT	ROMANIA	BET
FINLAND	HEX	SLOVAKIA	SAX
FRANCE	CAC 40	SLOVENIA	SBI 20
GREECE	ATGI	SWITZERLAND	SWISS MARKET INDEX
SPAIN	IBEX	SWEDEN	OMXS
NETHERLANDS	AEX	UKRAINE	PFTS
IRELAND	ISEQ	HUNGARY	BUX
LITHUANIA	OMXV	UNITED KINGDOM	FTSE 100
LUXEMBOURG	LUXX	ITALY	S&P MIB

Source: developer by the authors.

The study was used data on Gross Domestic Product (GDP) *per capita* and the current account balance (in US dollars). The data for the period 2005–2008 were obtained from Eurostat and International Monetary Fund[11].

The VAR and DCC GARCH models were estimated using procedures derived from MFE Toolbox and UCSD Toolbox written by K. Sheppard in Matlab[12]. Besides, the Zivot-Andrews test procedure written in STATA was used[13]. The Geoda software package was used to visualize the results on the maps.

4.   RESULTS AND DISCUSSION

The analysis of the spillover effect based on the time of the break points in the stock markets' index trend showed that Poland was one of the countries where the stock exchange decline appeared the earliest. In addition to the Warsaw Stock Exchanges, major reductions in the stock price indexes were noted in Ireland, Sweden, Estonia and Hungary in July 2007. This means that besides the emerging markets, one of the first group of markets that reacted to the declines in the US stock exchanges was the stock exchanges in the developing countries. Interestingly, the declines in the second group were much weaker than in the emerging markets. As shown by the Zivot-Andrews test, stock indexes declined in the following group of countries two months after the date of the first stock market's structural break in the Europe (Ireland).

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[10] http://ideas.repec.org/c/boc/bocode/s437301.html, 01.05.2010.
[11] http://www.imf.org, 01.05.2010.
[12] http://www.kevinsheppard.net/wiki 01.05.2010.
[13] http://ideas.repec.org/c/boc/bocode/s437301.html, 01.05.2010.

As regards Sweden, its fast reaction to the bad news coming from the United States can be explained in terms of high risk aversion characterizing the Swedish investors in stock. According to Wärneryd, private investors predominate in the Stockholm Stock Exchange. Sweden has one of the highest percentages of households holding stock. This explains why stock investors in this country are less inclined to take risk than (for example) the Dutch investors[14]. Analyzing the OMXS declines we need to remember that Sweden has multiple links with other economies. The financial market is not only connected with the real sector, but it is also vulnerable to changes in the element of the other countries' financial systems. These relationships justify the high speed of the negative impulses' transmission from the USA. As a result, notwithstanding the satisfactory condition of the Swedish banking sector, its stock market was devastated by the mass sales of companies' assets.

The consideration of the chronological way of the negative information transmission induced to the OMX Tallinn index decline analyses. The index trend in the Estonian stock market changed one week after the break point in the Sweden stock occurred. In this case, trying to explain the break in the stock index trend only in terms of the US stock influence is apparently insufficient. The converging break point dates can be partly explained by the fact that both stock exchanges (i.e. Swedish and Estonian) use the same platform – OMX. Therefore, the two markets may show similar sensitivity to the negative shock. Moreover, impulse transmission between stock exchanges sharing a trading platform may be more synchronized than in the other cases. Another argument proving that the two stock markets are strongly interconnected is provided by the analysis of stock issuers. As regards the Estonian stock market, the main index is dominated by the banking institutions. Most of them are part of the Scandinavian financial groups[15].

The main index of the Warsaw Stock Exchange (WIG) also showed that the banking sector was a major issuer, in much the same way as the Estonian stock market index did. The decline in July 2007 can be explained in two ways. On explanation could be that it was a product of the strong ties linking shares issued by banks in Poland and assets issued by financial holdings in Europe and United States. Another possible explanation is that the decline in the WIG index was initially characterized by a statistically significant influence of the impulses from the US stock exchange. Moreover, the impulse generated by the European companies could only be noticed at the level of individual shares. In contrast to this situation, the decline in the main stock index was determined by both the reduction in the prices of banks' shares and the impacts of changes in the NYSE index.

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[14] Wärneryd K.E., [2001], *Stock-market psychology: how people value and trade stocks*, Edward Elgar Publishing Limited, Great Britain, pp.241–242.
[15] http://www.eestipank.info, 01.05.2010.

The situation in Western Europe under crisis was driven by different mechanism. First of all, the Belgian stock market index (BEL 20) declined – partly because of the signals coming from Europe and United States – some two months after the banking sector's shares fell. In 2007, the shares issued by the banks and the main stock index followed different patterns of decline, as shown by the analysis of BEL 20 composition. Among the shares of the 20 companies being part of the BEL 20, only 3 were issued by the banks – the KBC Group, Dexia and Fortis. Although the total weight of these shares was about 36% in 2007, the main stock market index in Belgium did not suggest that the investors lost their trust in financial institutions immediately[16].

Analyzing the time of the structural break in the trend characterizing the European stock price indexes, we can also see that the first phase of the decreases, which appeared in July 2007, was not followed by their second phase until October. This means that between August and September the trend in the stock indexes did not change at all. This situation remained stable until autumn, when more declines occurred. Two types of markets suffered from declines then. The first type was markets where the declines should be attributed to falling neighboring markets, whose shares fell first. The other group represents markets whose position in Europe is high.

For example, the declines in the Scandinavian stock exchanges initiated by the break point noticed in the Sweden stock exchange affected the other OMX stock exchanges, i.e. Norwegian, Finnish and Danish. Besides the Estonian stock, in October the group of the falling markets was joined by the other the Baltic states – Lithuania and Latvia. Regarding the Central European stock exchanges, decreases were found then in Poland, Hungary, Austria and the Czech Republic.

The second group of markets were those dominating the European stock exchanges. A reduction in the main stock indexes could be seen mostly in the developed countries – Belgium, Netherlands, the UK and Switzerland. It is worth noting that investors' behavior on these stock exchanges was caused not only by the problems in the United States, but also by the problems experienced by the financial institutions in Europe. An important observation is that major investors took into account the crisis-related spillover effect. As a result, the main stock indexes declining in Sweden and Ireland warned the investors against falls in all European stock exchanges. This led to an asset selling phase and related increases in investment risk in the UK.

It is worth noting in this context that the leading European stock exchanges contributed to the declines in the Scandinavian and Polish markets only to a limited extent. The weaker influence of the Western European stock exchanges and the increasing role of the United States with respect to the transmission of

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[16] http://www.euronext.com/fic/000/030/450/304502.pdf, 01.05.2010.

negative impulses was observed in the case of stock exchanges running on the OMX platform and for some Eastern and Central European stock exchanges. In the case of the Polish SE, an analysis of the major stock market indexes shows the Polish SE's limited connections with the Western European stock exchanges, thus emphasizing the impact of the situation in United States. Moreover, this type of an interaction was noticed during the crisis at the level of assets comprising the WIG (especially for shares issued by the banking institutions). The developed markets' impacts could be seen in the Western European countries. This means that the assets were reduced in France, Spain, Portugal and Italy mostly in response to the negative information coming from the leading stock markets in Europe. The investors interpreted the changing market trends in the markets as a symptom of weakening European stock exchanges, which are sensitive to impulses from United States.

The spatial scheme of spillover shows that the time of the structural breaks is related to the countries' membership in the euro area. In almost all these countries the break point in the stock market index occurred in the last quarter of 2007. Ireland is an exception, where the main stock index declined earlier. Ireland belongs to the group of countries that triggered stock market declines in Europe.

Figure 1 shows the times of the structural breaks in the European stock exchanges.

Fig. 1 Spillover of stock exchanges' declines in 2007 and 2008
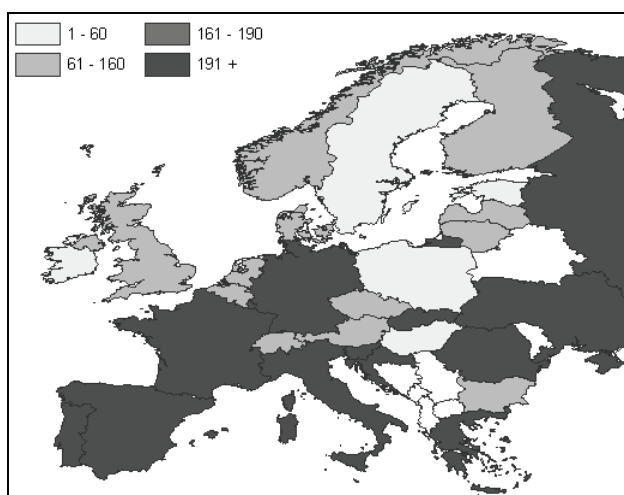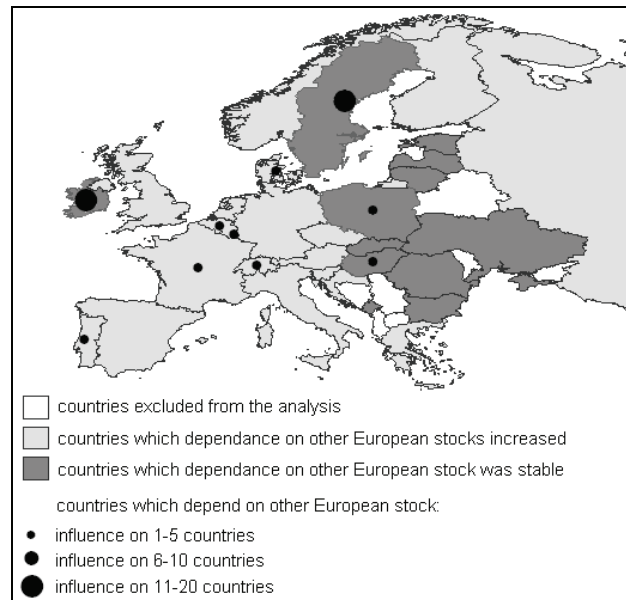

Source: calculated by the authors with Geoda.

The first stocks to have the break point were (identified with the Zivot-Andrews test) the Irish, Swedish and Polish exchanges. Their structural breaks appeared within two months from the first structural breaks in the Europe. Over

the next 100 days (from 61 to 160 days after the first main European index crashed), the index price index collapsed in Denmark, Finland, Norway, the UK, etc. For the next 30 days stock exchanges were falling in Western Europe. The stock markets indexes in countries such as Spain, France, Portugal, and Germany were declining for about 161–190 days after the first European index dropped.

When the results produced by the Zivot-Andrews test are compared with the Forbes and Rigobon (FR) test's outcomes, we can see that the break point timing (that determined the spillover process during the 2007 crisis) influenced the identification of the countries whose effect on the other markets grew stronger between 2007 and 2008. According to the FR test's results, the most important for the investors' loss of trust was falling stock exchange indexes in Ireland and Sweden. Besides, the FR test pointed to these countries as being a source of the stock index declines in other European countries.

The decrease in the ISEQ warned investors at the Western European exchange stocks that the fall had reached Europe. The decline in the Swedish n index played a similar role for the Scandinavian financial markets. In both cases, the stock exchanges –where the situation determined investors' behavior – were identified in the FR test as the sources of spillover.

Fig. 2 Relationships between changes in stock market indexes during the crisis 2007–2009

Source: calculated by the authors with Geoda.

The test's results show that during the crisis most of European markets characterized the rapidly growth of influence. Besides, the following stocks link the time of structural date (first in Europe). This proves that the FR test's results are mostly determined by the Zivot-Andrews test. Because of that, the results are sensitive to the structural break date that plays a key role in identifying the spillover sources and to relationships between the changes in the markets.

Except the following stock exchanges, the FR test indicates stronger impact of the WIG and the Hungarian BUX on other exchange stocks in Europe. As before, there is a connection between the dates of the break point in the stock index trend for the stock exchanges d and their leading role in the region. Although in stable periods both stock exchanges are only visible at the regional level, during the crisis their positions grew and they marked their presence at both intraregional and interregional levels. On the one hand, this proves the intraregional character of the spillover of the declines in the stock markets. One the other hand, the intensifying interaction between markets operating in different parts of Europe is connected with the interregional dependence.

Moreover, the FR test's results proves that the leading stock exchanges in Western Europe increased in the period 2007–2009. For example, the influence of the stock exchanges in Switzerland, Belgium and Netherland rose in case of France, Spain and Italy. Although these relationships were observable in both a stable period and crisis, their strength rapidly increased during the last crisis.

Unlike the Swedish, Irish, Polish and Hungarian stock exchanges whose influence was stronger than interregional during the crisis, the leading markets in the Western Europe affected the most strongly the neighboring stock exchanges. The strengthening of interregional relationships was particularly observable in Western Europe. Its argue the need of the analysis the economic and geography distance connections with the degree of interaction within Western Europe. As shown by figure 3, the differences in the mean conditional correlation coefficients depend on the period (the cyclical fluctuation) and the economic distance[17].

In the period in question, cyclical fluctuations could be observed in the conditional correlation coefficient values. This situation was found for countries having similar economies and for stock exchanges located in significantly different countries. Regardless of the distance between the markets, the strongest changes in the stock indexes' relationships were discovered between 2007 and 2008.

The first phase of the crisis (2007) was largely connected with the growing influence of the United States. The increasing role of the country was accompanied by the restructuring of the relations existing between Western European stock exchanges. The negative deviations from the mean conditional correlation coefficients reached their maximum value in 2007. This fact proves a weakening

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[17] The economic distance was defined as the Euclidean distance between countries based on the GDP *per capita* and current account balance.
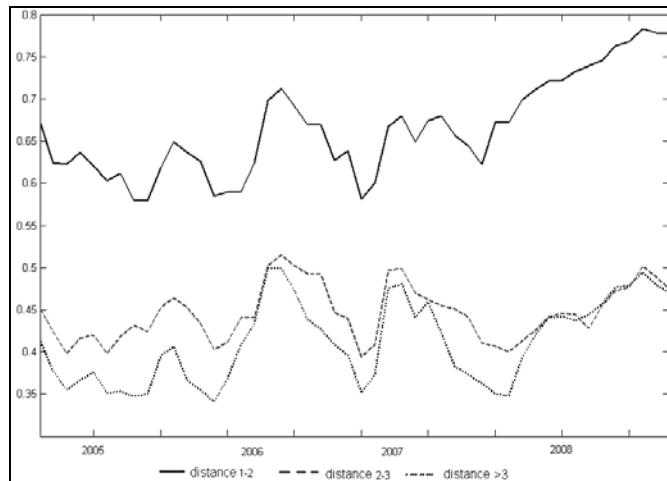
influence of the European stock exchanges and sharply growing impacts of the US market.

Fig. 3 Influence of the economic distance on the conditional correlation coefficient between 2005 and 2008
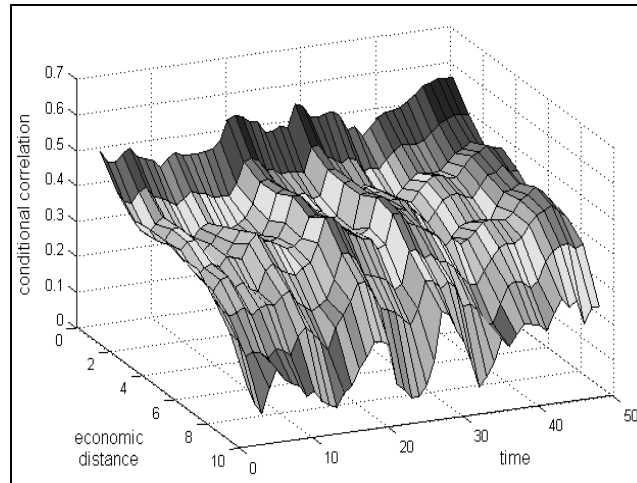
Source: calculated by the authors with Matlab.

Fig. 4 Relationships between the mean conditional correlation coefficient and the Swiss Market Index returns and economic distance

Source: calculated by the authors with Matlab.

The interactions between the declines in the European stock exchanges were observed only in 2007. During the second phase of the stock markets crisis (2008) the degree of conditional correlation between the main stock market indexes increased. For most European stock indexes the mean conditional correla-

tion was higher in 2008 than in the years 2000–2008. The increased correlation between the markets of most countries resulted from the same or similar trend in stock index returns, as well as the similar reactions of investors.

The analysis of the relationships between the mean conditional correlation coefficient and the mean economic distance (for years 2005–2008) shows certain regularities. The changes in the conditional correlation coefficient were accompanied by varying markets' impacts depending on the similarity of the countries' economies.

It is important to know that changes in the conditional correlation coefficient are the most susceptible to economic distance measured by GDP *per capita* and balance of trade. Figure 4 shows that the conditional correlation value declines as the economic distance becomes larger. The influence of the economic distance dependence on the relationships between the stock markets is the most distinct for the closest economies. It is noteworthy that the economic distance determines the level of conditional correlation, but its degree country specific. For example, the Swiss stock market index (SMI) correlates the most strongly throughout the period in question with stock exchanges located in countries having the most similar economic situation. The highest value of the conditional correlation is found for the relationships with:

–   The Netherlands – the mean conditional correlation value between the SMI and the AEX was 0.78 (the economic distance between Switzerland and the Netherlands was 1.9);

–   Belgium – the mean conditional correlation with the BEL 20 was 0.73 (the economic distance between Switzerland and Belgium was 1.3);

–   France – the mean conditional correlation with the CAC 40 was 0.75 (the economic distance between Switzerland and France was 2.4);

–   Great Britain – the mean conditional correlation with the FTSE 100 was 0.74 (the economic distance between Switzerland and France was 2.4).

No relationships between the level of conditional correlation and the economic distance were found for Switzerland, on the one hand, and Austria and Italy, on the other. Although the Switzerland's mean value of conditional correlation with Italy was 0.66, the economic distance between the countries was much bigger than that between Switzerland and Austria (the mean conditional correlation of 0.57).

The analysis of the economic distance impact on the degree of correlation showed that the importance of the distance varies between countries. For example, changes in the relationships between SMI and other markets were the most evident for the economic distance given as 1–2. For high differences between the economies, the conditional correlation coefficient had a similar, lower value. The results aggregated for all European stock exchanges (fig. 5) showed that the strongest impact of the economic distance can be seen in the most similar countries. Basically, the most correlated stock exchanges are located in countries

where the economic distance does not exceed 0.5. This group encompasses the following pairs of countries: UK–Italy, Finland–Denmark, France–UK, Spain–Portugal and Austria–Belgium.

Fig. 5 The average conditional correlation depends on the economic and geographical distance (neighborhood)

—— neighborhood – – – no neighborhood   —— distance 0-0.5 – – distance 0.5-1 ···· distance >3
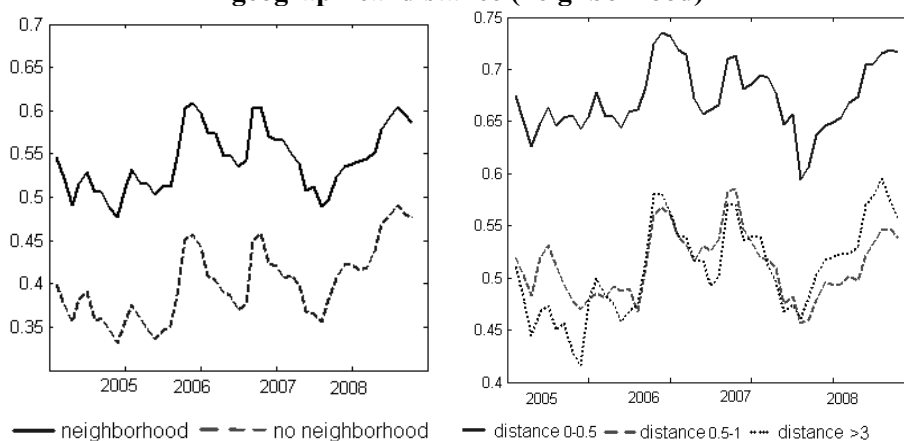
Source: calculated by the authors with Matlab.

In addition to the impact of the economic distance, the relationship between changes in the indexes also results from the stock exchanges' location in the space approximated by neighborhood. The nature of the fluctuations in the mean conditional correlation coefficient (the mean for all studied markets) is the same whether neighborhood occurs or not. However, the mean conditional correlation coefficient is greater for stock exchanges located in the neighboring countries. This regularity could be observed in the entire period in question (between 2004 and 2009). It means that the degree of the conditional relationships between the markets arises from neighborhood and economic distance.

5. CONCLUSIONS

The declines in the main stock market indexes in Europe that began at the turn of 2007 were one of the first symptoms of the looming crisis. The analysis of changing relationships between stock markets located in the European countries showed that the level of impact between the stock exchange changed then. The results produced by the adjusted VAR model and the FR test point to the role that stock exchanges played in the crisis spillover in 2007. In addition to being exposed to the impacts exerted by the major Western European markets, the stock index also changed because of structural breaks in the stocks which noticed as the first in Europe decline.

The conditional correlation coefficients – that were estimated for every pair of stock exchanges – demonstrated that the level of the relationships linking the markets changed between 2007 and 2008. After the level of correlation decreased in 2007, its value rapidly grow. This proves the dominant nature of the ubiquitous downward trend characterizing European stocks.

Each pair of indexes was assigned the pertinent economic distance between countries where stock exchanges are located. This process revealed the volatility of the relationships between stock markets depending on the similarities between countries' economies. The method used in this study approximated geographical distance using the elements of a neighborhood matrix. It proved the existence of relationships between the degree of conditional correlation of stock indexes and the spatial proximity of the markets.

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Wpływ przestrzennych i ekonomicznych odległości na zmiany relacji pomiędzy europejskimi rynkami papierów wartościowych w okresie kryzysu 2007-2009

Wpływ zależności przestrzennych na kształtowanie się walorów giełdowych staje się coraz częściej przedmiotem dyskusji. Podejmowane próby określenia wpływu odległości na wybory dokonywane przez graczy giełdowych dotyczą zarówno relacji w obrębie danego rynku giełdowego, jak i między nimi. W przypadku tych ostatnich, relacje przestrzenne stanowić mogą kanał transmisji szoku, prowadząc do wystąpienia efektu zarażania.

Celem pracy jest prezentacja wyników badań dotyczących wpływu odległości geograficznej i ekonomicznej na stopień skorelowania wybranych rynków giełdowych Europy w dobie kryzysu z lat 2007–2009. W celu zweryfikowania hipotezy dotyczącej wpływu zależności przestrzennych na siłę relacji międzygiełdowych wykorzystano model DCC GARCH oraz narzędzia analiz przestrzennych.