CONNECTEDNESS OF STOCK MARKETS IN EASTERN AND CENTRAL EUROPE

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Abstract
This paper investigates the connectedness of volatility and market return inside the Central and Eastern European Market, particulary between the Central European cluster consisting of Poalnd, the Czech Republic, Slovakia, Austria and Hungary, and the East European Cluster consisting of Romania Bulgaria and Grece. We use the financial stock market as we consider the stock market to be an important source of financing for companies and that the stock market represents an important part in the economical environment of these countries. The paper analysis multiple methods of approaching connectedness problems, however will use the one based on dynamic connectedness analysis. We will analyze the data from a perspective before the financial crisis, during the financial crisis and after the financial crisis up to December 2019. We find a shift in geographical connectedness over the years, as well as a shift inside the peer group itself. It appears that larger more mature markets such as the Austrian have a clear dominant status in the region. We can also infer that the Romanian market showed signs of developing into a regional hub, compared to Bulgaria, which has very little significance in the region. In addition, the Greek market has lost significant influence in the region, driven by its economic and political turmoil over the last decade.

Keywords
Connectedness, stock market, volatility, return, Central Europe, Eastern European.

JEL Classification
F15, F36, G15.

Introduction

The theory of international diversification began in the 1970s with the work of Levy and Sarnat (1970) and Solnik (1974). The basic idea of international diversification is that market risk is specific to every country; therefore, diversifying across different country-risks lowers the portfolio risk. This argument is based on the fundamental idea that markets should act independent. In recent years, through the process of globalization, increasing international capital flow, and expansion of common markets such as the EU and its waves of extension,

we find reason to believe that some markets and some regions do share a common market risk, as we will conclude from the included literature. This paper will research the idea of connectedness through volatility and market return inside two distrinct but geogprahically linked „EU Clusters", Central European consisting of Poland, the Czech Republic, Slovakia, Austria and Hungary, and Eastern European consisting of Romania Bulgaria and Grece. Since the EU consists of independent countries that trade inside a common market, the question of market connectedness becomes very relevant. How connected are these markets and if they are connected, has this relationship changed in the last years?

The underlying assumption behind international diversification is that phenomena specific to individual countries affect returns in that country. If there is a relationship between individual markets, represented in the research to follow by the market index, this may lead to high cross-border interdependency between national indices. Potential gains from international diversification depend on the interdependence structure of the indices for various global markets in each period. At the same time, for example, industry correlation, if favourable, can lead to higher returns for a given sector cross-border, increasing the reputation of that industry. The underlying assumption is that if there is a return or volatility connectedness, there might also be a return spill-over effect from the interdependence of markets. More so, this relationship can change over time. As Diebold and Yılmaz (2015) show in their research, the reason why indices are a good indicator for connectedness is because they are built of stocks pertaining to large corporations that operate out of the individual country. "Stocks are priced based on expected future cash flow, which in turn is linked to economic activity. The resulting forward-looking perspective makes the stock market the most important barometer of current and expected future economic activity."

One can argue that the analysis consists of primarily emerging financial markets. These markets might have lower capitalization than their peers, but as they are more or less similar in maturity, with some exceptions, the analysis should show if there is a capital markets interconnectedness driven by geographic proximity.

This paper will use econometric methods as presented by Diebold andY ılmaz (2015) to test three separate periods and analyse evidence of connectedness, by using the Variance Decomposition using Cholesky (d.f. adjusted) factors of vector auto-regressive ("VAR") models by taking the 2nd degree lag and preparing a so called connectedness table. The methods will be better shown in the analysis chapter of this paper. The periods are not congruent, as we do not have daily high, low, opening and closing prices for all leading national indices prior to January 2007. The first period will be prior to 2008, consisting of the start of the financial crises. The second Period consists of 2008 until 2013, assuming that 2013 represented the end of the financial crisis and its repercussions, and a 3rd period consisting of 2014 until today (Dec'19), marking a period of stability and economic growth and therefore normal market conditions. Assuming connectedness exists, the effect can be explained by several economic reasons such as: volume of trade, flow of capital, or geographic proximity. If this is the case, the reasons for connectedness remain open to future research.

Recent research has focused on the relationship of international stock indices and the consequences of these changes on diversification and hedging. The results are controversial, and often yield contradictory results depending on the timeframe and restrictions imposed. New approaches are being developed to investigate the time-series movements of international stock markets. The aim of the literature review chapter is to present the most relevant findings in this field, as well as better explain the implications of international interdependence.

Review of the scientific literature

In the last years, significant research has been published focusing around connectedness, spill-over, contagion or other similar key words referring to a similar idea, a relationship that is not

fundamental in nature, that results in a irrational link between supposedly independent markets. Albulescu et al. (2015) evaluate the contagion from the perspective of futures contracts. The use of futures prices and not stock indices avoids the problem of market temporality. A study on the effect of the subprime crisis on the integration of stock market futures markets shows that the one in 2007 does not seem to affect the long-term movements between stock market futures markets. They use Wavelet Continuous Transformation (CWT). The analysis shows that futures markets grow in correlation during the crisis. They conclude that risk managers who want to benefit from portfolio diversification must have a long-term strategy to avoid contagion episode.

Asgharian and Nossman (2011) analyse how the capital markets of EU countries and the US capital market are affected. They simultaneously address all three aspects of market interactions, namely correlation, the effect of volatility and contagion. They look at the shocks that occur in every capital market in the EU, the United States and the idiosyncratic or local shocks, using a more general volatility model, such as the stochastic volatility model. More importantly, the model allows for the existence of leaps in profitability and volatility. Their method makes it possible to identify the contagion and directly model cross-border events. Their results show the contributions of the United States to the country variations that are generally below the contributions on the regional (European) market. The degree of integration in the EU, and automatically of European markets increases with the development of the European Union. They conclude that much of the volatility effect is due to regional markets but to a lesser extent to the US market.

Diebold and Yilmaz (2008), who are by now considered the norm in the field of connectedness, are interested not only in the volatility of financial markets and the contagion effect, but also in the link between macroeconomics, fundamental data and the volatility of asset profitability. They propose an international cross-sectional analysis between stock markets, GDP and the consumer index covering about forty countries. They show a clear link between macroeconomic factors and stock market volatility, so that volatility in macroeconomic factors leads to volatility in stock markets. This analysis was made for different periods from 1983 to 2002. Although the causal link is not permanent, and is specific to certain countries, it exists, and is reflected not so much in profitability as in the volatility of profitability. They show that the volatility of the stock market is robustly and positively related to the volatility of fundamental economic indicators. The positive relationship between the stock market and fundamental volatility is clear. They (Diebold and Yilmaz, 2011) continue to analyze the connectedness, based on the contagion index proposed by Diebold and Yilmaz (Diebold and Yilmaz, 2009) which they apply in terms of profitability and volatility in five countries in North and South America: Argentina, Brazil, Chile, Mexico and the USA The results indicate that the contagion effect on both profitability and volatility differs greatly. However, the effects correspond closely to the economic events from January 1, 1992 to October 2008 at a weekly interval. The study of the periods without crisis, as well as those of crisis, 1992-2008, identifies that in both periods there is evidence of divergent behavior both in the contagion of profitability and in that of profitability. As their analysis is the most complex and in-depth from the proposed methods, we will base the analysis on a slightly altererd variation of their analysis.

Methods and analysis

We have collected daily national indices prices from Bloomberg for the period 01 January 2007 until 31 December 2019, for the WIG in Poland, PX in the Czech Republic, SAX in Slovakia, ATX in Austria BUX in Hungary, BET in Romania, SOFIX in Bulgaria and the ASE in Grece. The sample includes daily high, low, opening and closing prices, resulting in 6.300 data points. The data was normalized by using the average between two points for the missing data, resulting from bank holidays in different markets/countries.

We divided data into three periods:

- January 2007 to December 2007 (Period 1), particularly the first year that Romania and Bulgaria became EU members. Note prior to this period we did not have consistent data points for all indices, particularly Bulgaria's SOFIX.
- January 2008 to December 2012 (Period 2), as a period representing the financial crisis and sovereign debt crisis in the EU.
- January 2013 to December 2019 (Period 3) to reflect the post financial crisis period.

We did not complete the dataset up to April 2020, do avoid the impact of the corona virus on the sample.

We used in our experiments daily returns computed as the natural logarithm of the daily closing price over the opening price, and daily annualized volatility using two approaches. The Parkinson volatility estimator as presented by Shu (2006) and the Garman and Klass (1980) volatility estimator, as adjusted by Alizadeh et al. (2002). We then proceed to build the connectedness table as defined by Diebold and Yılmaz (2015). We reject the null hypothesis, the data does not have a unit root at 5% significants level, the , hence both returns and volatility are stationary, Jarque–Bera test indicates rejection of the normality hypothesis, there are 8 cointegration equations at the .95 level of confidence, hence we will use max 8 lag. We move on to build the connectedness tables on hand of the variance decomposition of the VAR model. For the sake of space and time, we will not provide the full formulas and derivation of the methodology in this paper. We will also not show the Parkinson volatility in this paper, as the general relationship is one to one the same as the Garman and Klass volatility approach. We argue that from the two estimates, the Garman Klass incorporates more information on daily events, and hence provides is a better variance decomposition for volatility.

Findings

After running the experiment, we identified that both return and volatility show a clear picture of the direction of return shocks and volatility shocks in the Central and Eastern European region. The results (table no. 1 and table no. 2) contain valuable information on several layers of return and volatility connectedness in the region. The experiment shows that from all possible forms of geographic and economic connectedness over the period close to a third of the forecast error variance comes from connectedness, both for volatility (28,7%) and returns (29,5%). Though not significant capital flows between these countries, as most of them are driven by more developed economies such as Germany, there is still a certain geographical component to connectedness.

Table no. 1 Return connectedness table - period 2007-2020

2007 - 2020	ATX	WIG	PX	SAX	BUX	BET	SOFIX	ASE	From
ATX	94,3	1,2	0,6	0,9	0,5	1,1	0,9	0,5	*5,7*
WIG	21,2	76,2	0,5	0,7	0,6	0,4	0,1	0,3	*23,8*
PX	39,1	7,6	50,4	0,9	0,3	0,8	0,7	0,1	*49,6*
SAX	39,5	7,8	0,8	49,3	0,7	0,6	0,9	0,3	*50,7*
BUX	17,9	11,7	3,2	2,0	63,8	0,5	0,7	0,2	*36,2*
BET	23,6	1,4	2,4	1,3	0,2	69,8	0,9	0,2	*30,2*
SOFIX	7,8	1,7	2,1	1,6	0,6	2,7	83,1	0,5	*16,9*
ASE	16,0	2,5	1,6	1,0	0,5	1,4	0,4	76,7	*23,3*
To	*165,1*	*34,0*	*11,2*	*8,3*	*3,3*	*7,5*	*4,8*	*2,2*	
Net	**159,4**	**10,2**	**-38,4**	**-42,4**	**-32,9**	**-22,7**	**-12,1**	**-21,2**	**29,5**

Source: Own research

As expected, the ATX is the leading index in the region, as it has significant business exposure to other less capitalized markets. We note that the second largest effect to other markets is represented by the Polish market, which also has increased in importance over the last years, as the polish economy has grown significantly over the last years. We note that the Czech Republic and Slovakia are highly connected to the Austrian market, given their geographic proximity and historical connections. The same applies to the Romania and Hungarian Market, which show the same connection, to a lesser extent to the Austrian market but not to each other.

Table no. 2 Garman and Klass volatility connectedness table - period 2007-2020

2007 - 2020	ATX	WIG	PX	SAX	BUX	BET	SOFIX	ASE	From
ATX	92,4	3,0	0,6	0,8	0,3	0,7	2,3	0,1	*7,6*
WIG	23,3	73,1	0,8	0,5	0,7	1,1	0,5	0,1	*26,9*
PX	38,6	8,0	48,3	0,3	0,1	1,6	2,9	0,1	*51,7*
SAX	39,5	8,9	0,9	49,2	0,4	0,3	0,7	0,2	*50,8*
BUX	21,5	9,8	2,8	1,3	60,4	2,0	1,8	0,5	*39,6*
BET	19,3	3,5	2,2	0,3	0,3	72,9	1,4	0,1	*27,1*
SOFIX	11,4	0,4	0,7	0,3	0,3	1,5	85,2	0,2	*14,8*
ASE	6,4	1,5	1,1	0,3	0,7	0,4	0,3	89,3	*10,7*
To	*159,9*	*35,0*	*9,1*	*3,8*	*2,9*	*7,6*	*9,8*	*1,2*	
Net	**152,2**	**8,1**	**-42,6**	**-47,0**	**-36,7**	**-19,5**	**-5,0**	**-9,4**	**28,7**

Source: Own research

Finally, we notice that the Bulgarian index does not follow the normal trends in the region, given probably by its limited capitalization and exposure to the region. While the Greek market responds to shocks from the region, it does not influence the other markets, as they do not have close industrial ties with the region. Interesting to note that the polish market has both a leading tendency as well as a lagging tendency, in the sense that it encompasses the geographic exposure. However, the full-sample analysis overlooks many details that are crucial to understanding connectedness over time; hence, we resume the same analysis over the 3 periods, as defined above.

When looking at the periods independently as seen below (table no.3), we notice that volatility connectedness appears to be decreasing. While in 2007 the forecast error variance from connectedness for volatility is 43,2% and returns 44,2%, it drops in the financial crisis period to 36,4% for volatility and 28,1% for return, only to drop again after the financial crisis to 18,7% for volatility and 20,8% for return. There appears to be a trend in de-connection in the geographic area. Interesting to note that while the Austrian market remains the dominant market in the region, the influence of other markets on the Austrian market becomes minimal. Consistent with the growth of the Polish economy and its role as an important capital market in Eastern and Central Europe, the WIG has surpassed geographic influence, resulting in a market that is not influenced by neighboring markets. We note that the Czech, Slovakian and Hungarian Market have registered an increasing connectedness from their peers during the financial crisis, consistent with markets moving together during financial downturns. The same applies to the Bulgarian market. We note that the BET has continued to gain independence from other neighboring markets, despite the financial crisis. This is consistent with the facts that the BVB ("Bursa de Valori Bucuresti") has increased in importance in the region, developing to a regional hub. The Romanian market continues to be strongly influenced by the Austrian market, consistent with the high volume of capital with this country, through its financial institutions. The Bulgarian market on the other hand appears to

have a minimal connectedness to its EU neighbors. This is also consistent with the national/local capital market in Bulgaria. To note is finally also the declining importance in the region of the Greek market, also consistent with the political and economic events that have deteriorated the financial system in Greece over the last decade. We note that we have only added the Net return summary for the connectedness table, as the trends in development are identical. Of course, the impact the forecast error variance for return differs, however this paper investigates trends and not the forecasting possibility.

Table no. 3 Garman and Klass volatility and net return connectedness

	Period	ATX	WIG	PX	SAX	BUX	BET	SOFIX	ASE	From
ATX	1	78,3	3,7	4,3	3,4	1,7	1,0	2,2	5,6	*21,7*
	2	89,5	4,5	0,8	0,9	0,6	1,0	2,7	0,0	*10,5*
	3	95,6	0,8	0,5	1,9	0,6	0,2	0,2	0,2	*4,4*
WIG	1	28,6	53,7	3,7	2,6	1,4	1,7	4,5	3,8	*71,4*
	2	27,1	65,4	1,8	1,0	1,7	1,7	1,0	0,3	*72,9*
	3	11,6	86,4	0,2	0,5	0,6	0,1	0,4	0,2	*88,4*
PX	1	33,8	6,5	40,0	2,9	3,7	1,2	2,5	9,2	*66,2*
	2	39,3	11,1	41,3	1,0	0,7	2,9	3,2	0,4	*60,7*
	3	32,0	2,3	61,7	1,9	0,9	0,1	1,0	0,1	*68,0*
SAX	1	37,4	10,9	4,2	38,1	2,2	3,1	2,1	1,9	*62,6*
	2	42,0	14,0	1,4	40,3	0,8	0,5	0,6	0,4	*58,0*
	3	30,2	4,8	0,8	62,7	0,8	0,4	0,2	0,2	*69,8*
BUX	1	16,3	10,0	4,5	4,2	55,8	2,7	3,8	2,7	*83,7*
	2	23,9	14,2	3,2	2,0	51,3	3,2	1,6	0,6	*76,1*
	3	13,1	2,4	2,2	1,1	80,3	0,1	0,4	0,4	*86,9*
BET	1	7,7	6,1	2,3	3,4	3,9	65,7	6,6	4,3	*92,3*
	2	20,7	3,9	2,1	0,6	0,3	70,5	1,7	0,3	*79,3*
	3	17,9	1,8	4,4	0,7	1,2	73,7	0,1	0,2	*82,1*
SOFIX	1	2,8	3,4	1,6	1,5	1,4	1,3	85,1	2,8	*97,2*
	2	18,4	1,1	1,0	1,1	1,1	2,0	75,0	0,3	*81,6*
	3	0,7	0,6	0,4	0,2	1,0	0,4	96,3	0,3	*99,3*
ASE	1	39,6	7,3	5,8	3,9	1,3	1,0	3,3	37,9	*60,4*
	2	13,3	3,2	2,0	1,2	2,5	1,8	0,7	75,3	*86,7*
	3	2,5	1,0	1,5	0,2	0,3	0,3	0,2	94,0	*97,5*
To	1	*166,3*	*47,9*	*26,3*	*22,0*	*15,5*	*12,0*	*25,0*	*30,4*	
	2	*184,7*	*52,1*	*12,3*	*7,6*	*7,7*	*13,1*	*11,6*	*2,3*	
	3	*107,8*	*13,6*	*10,1*	*6,5*	*5,5*	*1,5*	*2,7*	*1,6*	
Net	1	144,5	1,6	-33,6	-39,9	-28,7	-22,4	10,1	-31,7	43,2
Volatility	2	174,2	17,5	-46,4	-52,1	-41,0	-16,4	-13,4	-22,4	36,4
	3	103,4	0,0	-28,2	-30,8	-14,2	-24,7	-1,0	-4,4	18,7
Net	1	119,7	8,3	-10,4	-35,9	-21,4	-20,6	-15,6	-24,0	44,2
Return	2	178,1	18,6	-38,8	-45,0	-37,8	-25,9	-16,0	-33,3	38,1
	3	120,5	1,0	-37,9	-34,1	-22,2	-15,4	-2,3	-9,7	20,8

Source: own research

Conclusions

We have analyzed the connectedness of EU member states in Central and Eastern Europe, and have concluded that there was a shift in both geographical connectedness over the years, as well as between the peers itself. It appears that larger more mature markets such as the Austrian and newly the Polish market have a dominant status in the region, while smaller markets connect to regional hubs. We can also infer that the Romanian market has shown signs of development towards a regional hub, compared to Bulgaria, which has very little significance in the region. Thirdly, we can conclude that the Greek market has lost significant influence in the region, driven by its economic and political turmoil over the last decade.

While the decomposition of a VAR using Cholesky (d.f. adjusted) may be influenced by the ordering structure and definition of volatility and return, we clearly observe that the trends shown are consistent with the economic reality in the region, delivering a numeric true big picture of how connectedness works in these regional markets.

It is important to note that the connectedness method (Diebold and Yılmaz, 2015) method of analysing connectedness and their proposed connectedness table accurately reflected the situations of the periods.

The question that comes out of this research is, has there been a shift in connectedness from these countries towards more mature markets, making the linkage in connectedness more global?

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