CONTAGION AND INTEGRATION OF CAPITAL MARKETS IN THE CEE COUNTRIES

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Abstract: *The purpose of this article is to study the contagion and the integration regarding the capital markets in Central and Eastern Europe (Romania, Hungary, Poland and Czech Republic). We will analyze the dynamics of correlation between these markets and the Eurozone over time. The methodology will be consisted of classical methods such as rolling-window Pearson correlation or more complex methods based on the correlation obtained using DCC-GARCH. At the same time, the results will be interpreted in the context of a diversified portfolio and will take into account the specificity of these markets and the phase of the economic cycle. The results revealed that the integration of the capital markets with the Eurozone markets has increased over time and the correlations were stronger. At the same time, increased integration has led to more pronounced contagion during the 2008 economic crisis.*

Keywords: *contagion; financial integration; time-series; volatility; correlation; equity markets.*

JEL Classification: *G15; C22; G11.*

1. Background

The integration of financial markets in Central and Eastern Europe has been a strong topic in recent years in the literature, especially in the aftermath of the economic and financial crisis of 2008. Global capital markets have become more interconnected and those in the Eastern European countries have not made an exception. The integration of capital markets has been supported in particular by the intensification of trade flows between states, their economies becoming more and more connected and more synchronized.
Integration of financial markets leads to the unification of markets and the reduction of frictions, and in this respect globalization has played an important role. On the other hand, there are a lot of theories, such as the modern portfolio theory, which suggests that the integration of capital markets leads to a reduction in the benefits of diversification, while all markets react in the same way. Thus, we can talk about the concept of contagion in the context of a crisis. The effects of a negative shock is transmitted very quickly in the context of an integrated capital market, bringing us to the idea of a higher contagion risk. However, beneficial effects could be more numerous than negative ones.
The level of integration and the risk of contagion can be measured by various instruments, and the literature is very extensive. Classical methods of beta-

convergence, sigma-convergence, rolling-window Pearson correlation, or different models that capture market correlation and conditional volatility, can be applied as tools for measuring contagion and integration. From the category of these models we can remember the class of multivariate GARCH models, and finally we can go to the CCC-GARCH or DCC-GARCH models.

Taking into consideration all of these and the researches from the literature, we aim through this paper to measure the correlation and integration between capital markets in the Central and Eastern Europe. The novelty is not represented by the applied methodology, but the markets for which it is applied and the way how we tested the benefits of the methodology and how we placed it in the context of a portfolio management. It should be noted that the study will be conducted for the following eastern European countries: Poland, Hungary, Romania, Czech Republic, compared to the Eurozone. This methodology will pursue to estimate the dynamics of the correlation between these capital markets using a dynamic conditional-correlation autoregressive conditional heteroscedasticity (DCC-GARCH) model. At the same time, we will look at the benefits of using this model versus a Pearson coefficient (Pearson Correlation) and will present how the results can be used in the context of a equity portfolio management.

Thus, this paper is designed to study the correlation in capital markets from Central and Eastern Europe and the Eurozone, but also the manner in which this correlation has evolved over the last 18 years. It is considered that the correlation measure is a good indicator for the integration of financial markets or for contagion, and it is important to follow the evolution according to market events. At the same time, the benefits of DCC-Garch's correlation over Pearson Correlation will be highlighted in the context of a portfolio. The analysis will be conducted over different periods of time (18 years) in order to capture a complete economic cycle in Central and Eastern Europe.

2. Literature Review

The literature regarding integration and analysis of contagion is wide and the approaches for this topic are different. They can study integration into the financial markets through the concepts of sigma-convergence and beta-convergence, as Babetskii, Komarek and Komarkova (2007) did, addressing the issue of financial integration in the countries of Central and Eastern Europe. Also, Babetskii, Komarek and Komarkova (2013) made a more recent analysis of the integration level based on sigma convergence and beta convergence, but this time they expanded it, alongside the capital market and other financial markets: the forex market, the money market and the bond market.

Another way to approach the concept of integration and contagion in the financial markets can be represented by the analysis based on GARCH models to estimate the correlations between the markets in the dynamics. Thus, basic papers can be taken into account for explaining GARCH models, such as those of Engle (1982), Bollerslev (1986), Nelson (1991) or Glosten, Jagannathan and Runkle (1993). These works have laid the foundation for univariate GARCH models in the literature and, starting from them, we can move on to multivariate GARCH models that allow for the estimation of correlations between financial markets in different countries. Thus, the methodology of this research will be in line with that proposed by Engle (2002) and then, by Diebold, Yilmaz (2009) addressing contagion and correlation

between different financial markets. Starting from these ideas, the present study will be carried out for the case of the countries of Central and Eastern Europe, including the case of Romania, in order to highlight the level of integration.
The literature has highlighted a number of advantages and disadvantages of financial integration. Thus, integration leads to lower transaction costs, increased competition, but also leads to lower benefits of diversification. Ferreira P. (2016) revealed in his paper that the increase in the level of integration leads to accelerating economic growth, to welfare growth due to better allocation of savings. On the other hand, if these benefits are not properly managed, they can generate imbalances, and these can be accentuated by high integration that favors high contagion. Thus, following the 2008 economic crisis, it has been revealed that an increase in market integration can sometimes bring major disadvantages in terms of increasing contagion or accelerating it. This topic has been addressed by Das D., Bhowmik P., ana Jana R. (2018), and by Panda A.K. and Nanda S. (2018), highlighting the fact that integration has brought a number of advantages but, on the other hand, exposed financial markets to a high risk of contagion in the face of an economic downturn or financial crisis. Thus, a financial crisis can be more severe when a number of markets are heavily integrated financially and commercially.
As mentioned above, there are numerous ways to study correlations, and the most recent are those based on conditional correlation obtained by applying multivariate GARCH models. This will be the general direction for this paper, and as a starting point we will consider the work of Paramati et al. (2016). He studied the relationship between the Australian stock exchange and the stock exchanges of its major trading partners, considering that their economies may be integrated to a certain extent. The authors used cointegration models and different types of DCC-GARCH (asymmetric dynamic conditional correlation-generalized autoregressive conditional heteroskedascity) to model the dynamics of the stock indices chosen for the analysis. Starting from this paper and from the researches identified in the literature, we will construct ower work for the case of of Central and Eastern Europe.

3. Data and Methodology

The purpose of this paper is to identify the extent to which Central and Eastern European capital markets are linked to the Eurozone, while also highlighting the integration process. At the same time, it will be highlight the added value of using DCC GARCH to measure the correlation in the context of am equity portfolio, taking into account the comparison with the use of Pearson Correlation with rolling window.
In this respect, we have chosen to analyze data relevant to the equity markets of each country. In order to capture the evolution of these markets, daily data were selected for relevant indices in each market for a period of 18 years, so as to include a complete economic cycle: economic growth, recession and recovery. Markets are considered to be correlated differently over different periods of the economic cycle. Further, we will present a synthesizer table for the data sets that are going to be used in the analysis:
We are going to use data for the main stock indices in Romania, Eurozone, Poland, Hungary and Czech Republic. The data will be daily, but the period for which data was used is 18 years: 01/01/2011 - 30/06/2018.

Table 1. Selected countries and their indices

Stock Market	Benchmark Indices	Frequency
Romania	BET Index	Daily
Eurozone	Euro Stoxx 50	Daily
Poland	WIG20 Index	Daily
Hungary	BUX Index	Daily
Czech Republic	PX Index	Daily

Source: Own computation

The data will be processed to be used within the model. It is necessary to obtain series of daily returns. For this purpose, we have used the following formula:

$$r_t = \ln(\frac{index_t}{index_{t-1}})$$

Volatility and asset correlation analysis has always been an important element in portfolio management debates. Thus, the knowledge of market correlations can provide information on the efficiency of diversification and how an equity portfolio from different markets can be managed. For estimating correlation there were used a lot of methods in the literature, such as Pearson Correlation, VAR, VECM, Granger causality, impulse response function, or different GARCH models. The results were different and the findings showed that each of them works properly in certain markets or in certain periods.

For this paper we have selected DCC-GARCH for correlation estimation. This model was developed by Engle R. (2002) for modeling time-varying volatility and correlationa between different markets. Also, Pesaran B. and Pesaran M.H. (2010) improved this model using it to estimate correlations, but assuming multivariate t-student distributions for heavy-tailed data modeling. Thus, starting from these papers, we will use the DCC-GARCH model for the Central and Eastern European markets and will see if this model brings value-added compared to Pearson Correlation in the context of a diversified portfolio of shares.

Further, we will try to outline the methodology behind estimating the DCC-GARCH model. The general equation for the DCC-GARCH model is presented below:

$$H_t = D_t R_t D_t$$

Where H_t – conditional variance matrix

D_t- diagonal matrix having conditional variance ($\sqrt{h_{it}}$) on its diagonals

R_t- is time-varying correlation matrix (off-diagonal elements)

Further, the conditional variance for each asset (h_{it}) is estimated using an univariate GARCH presented below:

$$h_{it} = w_i + \sum_{x=1}^{X_i} \alpha_{ix} r_{it-x}^2 + \sum_{y=1}^{Y_i} \beta_{iy} h_{it-y}, \ for\ i = 1,2,\dots,k$$

Where, $w_i, \alpha_{ix}, \beta_{iy}$are non-negative and $\sum_{x=1}^{X_i} \alpha_{ix} + \sum_{y=1}^{Y_i} \beta_{iy} \ < 1$; α_{ix}, is the short-run persistence of the schocks to returns Y to long-run persistence (the GARCH effects) and the number of assets is denoted by k.

ε_t are residuals and $\sqrt{h_{it}}$ - conditional standard deviation.

Furthermore, we are going to explain the elements from the general form of DCC-GARCH:

$$D_t = \begin{bmatrix} \sqrt{h_{11,t}} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sqrt{h_{kk,t}} \end{bmatrix}$$

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11}} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sqrt{q_{kk}} \end{bmatrix}$$

Q_t^* - diagonal matrix of its diagonal elements
Q_t is symmetric positive definite conditional covariance matrix
$\bar{Q}$ - unconditional covariance of the standardized residual of univariate GARCH models. Hence, we can write the following form:

$$Q_t = (1 - a - b)\bar{Q} + a\varepsilon_{t-1} - 1\varepsilon_{t-1}' + bQ_{t-1}$$

Also, we are going to use the classic form of correlation know in the literatura as Pearson Correlation. The well known formula is presented below:

$$\rho_{ij} = \frac{cov(i,j)}{\sigma_i \sigma_j}$$

4. Empirical Results

First of all, in order to interpret the results and to put them in an appropriate framework it is necessary to analyse them and it is necessary to present descriptive statistics for each of them. We recall that we used data series for 5 stock indices (BET Index, PX Index, WIG20 Index, BUX Index and Euro Stoxx 50). Based on these indices we have computed series of daily returns. Thus, we will provide descriptive statistics on performance data series.

Table 2. Descriptive statistics

	BUX	**BET**	**EUROSTOXX**	**PX**	**WIG20**
Mean (%)	0.032	0.061	-0.006	0.018	0.006
Median (%)	0.012	0.012	0.015	0.024	0.000
Maximum (%)	13.178	17.625	10.438	12.364	8.155
Minimum (%)	-12.649	-20.770	-9.011	-16.185	-8.443
Std. Dev. (%)	1.485	1.598	1.469	1.355	1.484
Skewness	-0.103	-0.330	-0.053	-0.487	-0.149
Kurtosis	9.511	21.122	7.621	16.490	5.740
Jarque-Bera	8304	64343	4181	35792	1487
Probability	0	0	0	0	0
Observations	4696	4696	4696	4696	4696

Source: own computation

Thus, it can be seen that the average yield for most indices was close to zero and the median was approximately equal to the average, which shows that we are working with about symmetric distributions. However, the Jarque Bera statistic suggests that the data series does not follow a normal distribution.

Out of the five selected markets, it can be noticed that the Romanian capital market recorded the most wide fluctuations with daily returns varying between -20% and 17.5%. On the other hand, for the Polish market there were the least variations in the daily yields of the stock market. To further highlight this aspects, we will also present a series of graphs on daily returns for 5 stock indices:

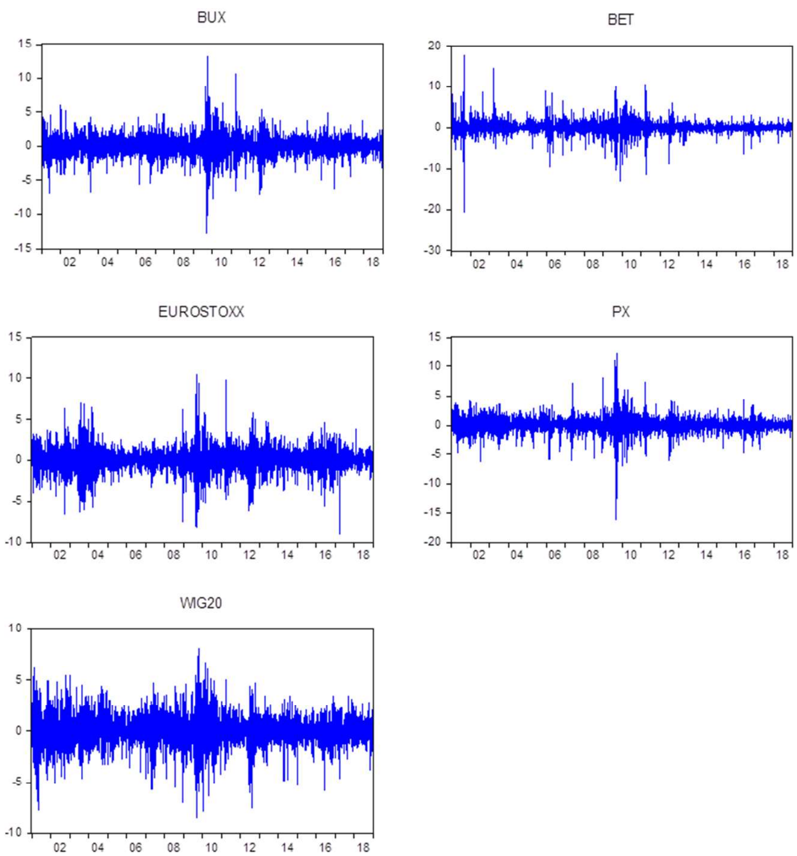

Figure 1: Daily returns for stock market indices
Source: Own computation based on the data published by each stock exchange

Also, in order to better know the data series that we will work with, we have made graphs that reveal a comparison between the empirical and theoretical distribution for daily returns.

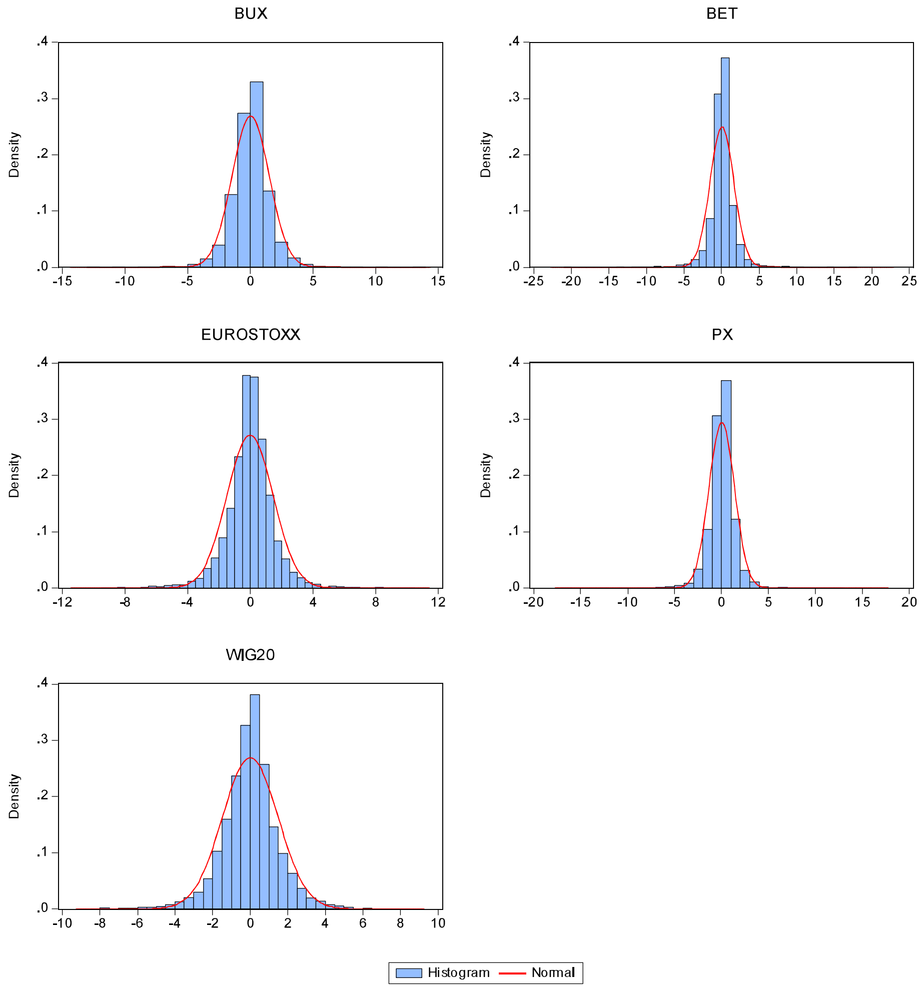

Figure 2: Empirical vs. theoretical distributions for daily returns
Source: Own computation based on the data published by each stock exchange

Based on these graphs, it can be argued that the daily data series for Euro Stoxx 50 and WIG20 are the ones that come closest to a normal distribution. On the other hand, the BET and PX series are the ones that are the most distant, with strong leptokurtic distributions. This is also evidenced by Table 2, where we presented the values for descriptive statistics. Thus, the kurtosis values calculated for BET and for PX are significantly higher than the level 3 specific for a normal distribution.
Further on, we will go to the presentation of the results obtained for the conditional correlation from DCC-GARCH for these markets versus the Euro Stoxx 50 Euro area capital market. At the same time, the conditional correlation will be presented compared to the Pearson correlation obtained using a rolling window. The calculation horizon was 01/01/2001 - 30/06/2018. We would like to remind you that we will follow how the correlation / integration has evolved, as well as the benefit of

using the conditional correlation from DCC-GARCH compared to a simple Pearson correlation in the context of a diversified portfolio. Thus, we will consider the modern portfolio theory, which asserts that once the correlations grow, the benefits of diversification decrease. Hence, this theory can be extended to the analysis of integration of the European capital markets: once the level of integration increases, the benefit of diversification through taking positions on different markets in Europe is decreasing.
The first chart that is going to be presented is related to the correlation between the capital market in the Eurozone and that in Romania. Therefore, we will still have a graph that highlights the correlation between the Euro Stoxx 50 and the BET using the DCC-GARCH and Pearson Coefficient.

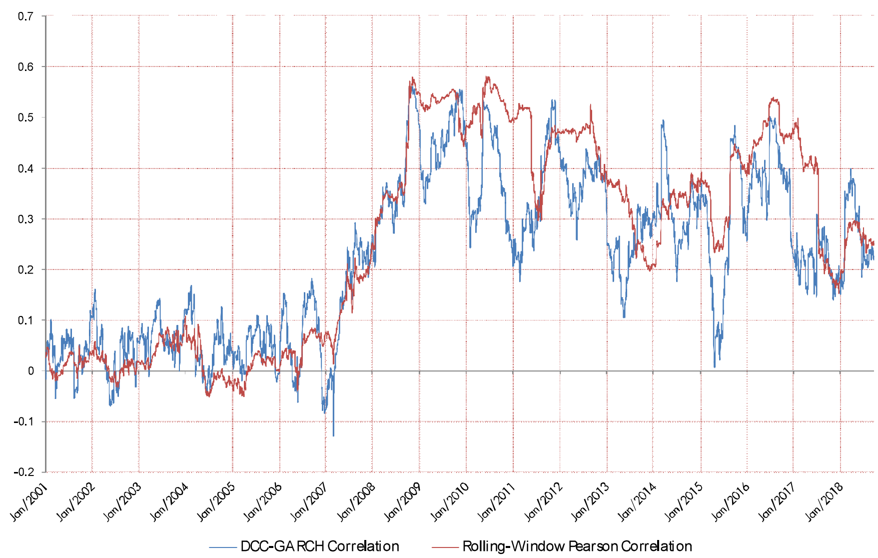

Figure 3: Conditional Correlation DCC-Garch vs. Rolling-Window Pearson Correlation (Euro Stoxx 50 vs. BET Index)
Source: own computation

The above graph highlights a number of very interesting and useful aspects of managing a diversified portfolio. Firstly, it can be seen that the level of correlation / integration of the two stock markets considered (Romania and the Eurozone) is increasing during periods of economic stress (global economic crisis 2008-2009). Also, after the accession of Romania to the European Union, the correlation between these markets has increased, even in periods without economic turmoil. Thus, we can say that the benefit of diversification drops sharply when there are turbulence on the market and has also fallen for the markets of Eastern Europe with the integration in the US, since they have become more correlated with the Eurozone markets.
On the other hand, it has been observed that the result obtained by applying the DCC-GARCH model has led to a series of correlations that are modeled more rapidly. The correlation obtained through this model is much more sensitive to

market developments, highlights trend shifts faster, responds faster, and can be more useful when managing a diversified portfolio. Thus, if we see an increase in correlation, we can see that portfolio diversification no longer adds value and should reduce exposures in several correlated markets. Conversely, when correlations decrease, a higher diversification is warranted. Therefore, it is necessary for a portfolio manager to have a tool to show it as soon as possible when market correlations change and the result of DCC-GARCH mode is more flexible and faster than that obtained by applying Pearson Correlation.
The results for the correlations between the WIG20, BUX and PX and Euro Stoxx 50 indices, ie the Polish, Hungarian and Polish capital markets and the Eurozone, will be presented in the same way. The graphs for conditional correlation using DCC-GARCH and Pearson Correlation will be presented, and interpretations will be made later for all three cases.

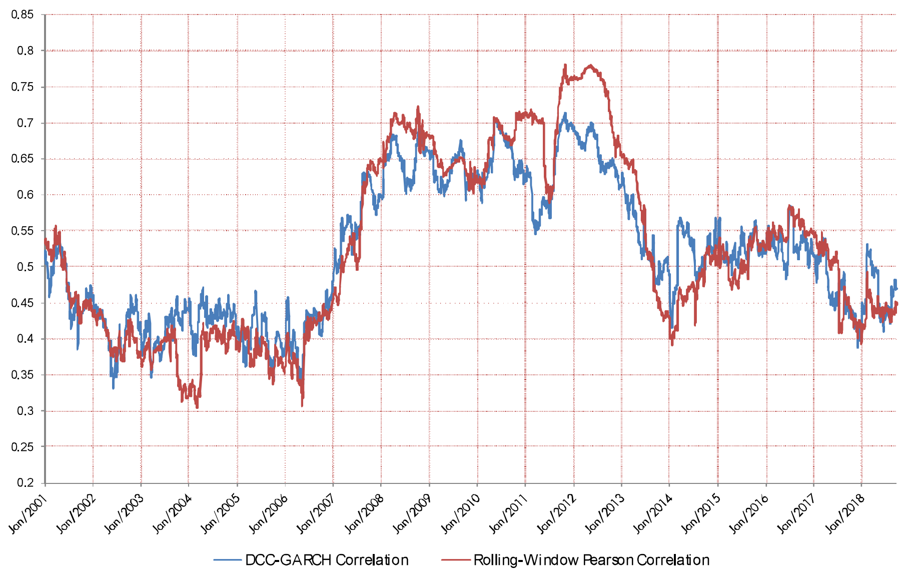

Figure 4: Conditional Correlation DCC-Garch vs. Rolling-Window Pearson Correlation (Euro Stoxx 50 vs. WIG20 Index)
Source: own computation

The first aspect that can be observed for the case of Hungary, Poland and Czech Republic is that the capital markets in these areas have been more closely linked to the Eurozone since the beginning of the analysis period, being countries already integrated into the European Union in 2003 -2004, when low correlation levels were observed for Romania. Thus, for that period, the diversification principle would have worked for the case of Romania and would have been less useful for the other 3 countries, being more closely related to the Eurozone market. On the other hand, it was again noticed that the degree of correlation increases significantly when there is a period of stress on the financial markets, just as it happened in the 2008 global economic and financial crisis. The correlation between the markets in Poland, Hungary and the Czech Republic and the Eurozone have increased, underlining that the principle of diversification has become less useful in these conditions, considering that markets have evolved to a great extent in the same direction.

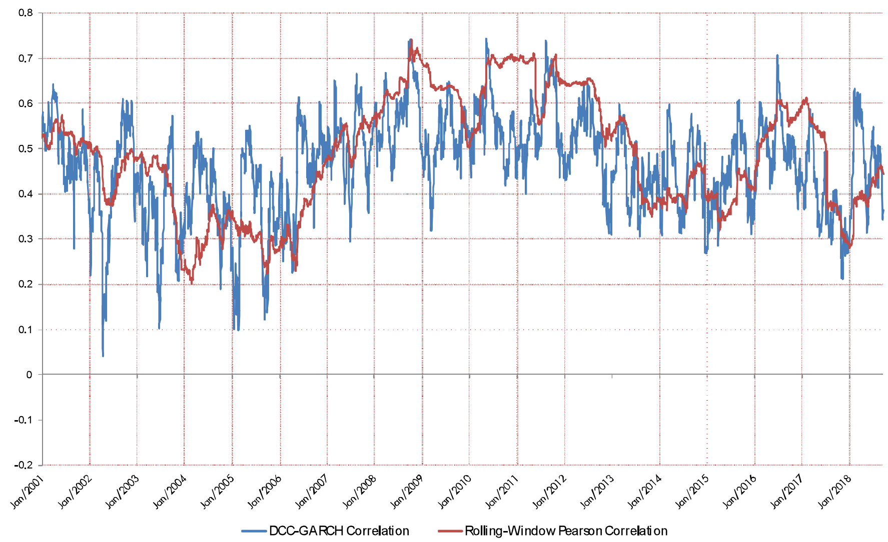

Figure 5: Conditional Correlation DCC-Garch vs. Rolling-Window Pearson Correlation (Euro Stoxx 50 vs. BUX Index)
Source: own computation

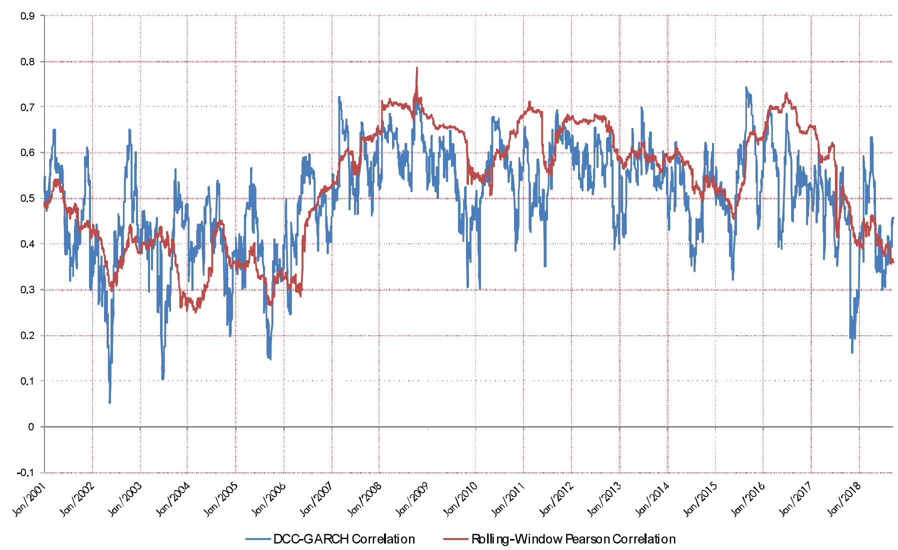

Figure 6: Conditional Correlation DCC-Garch vs. Rolling-Window Pearson Correlation (Euro Stoxx 50 vs. PX Index)
Source: own computation

Another important aspect that has also been validated in the case of the Romanian stock market: the correlation obtained using DCC-GARCH has proved more flexible than the rolling-window Pearson Correlation. Thus, it turns out that the DCC-GARCH model can be more useful in the context of a stock portfolio because it reacts faster and allows the fund manager to decide early on whether diversification makes sense or whether it can remain exposed only on certain markets, correlation to decrease. DCC-GARCH allows for greater flexibility and faster adaptation to the market compared to the rolling-window Pearson Correlation, where the reaction is slower.

5. **Conclusions**

The aim of this paper was to study the level of integration with the Eurozone for Central and Eastern European countries in terms of the capital market. Four countries were selected for study: Romania, Poland, Hungary and Czech Republic. It was intended to highlight integration and dynamics over the past 18 years using correlations calculated based on rolling-window Pearson Coefficient and DCC-GARCH model. It should also be noted that it was also highlighted how integration between markets can be considered when discussing the management of a diversified portfolio. Thus, a high correlation (high integration) makes the diversification principle no longer work. Moreover, a comparison was made between the two methods of estimating the level of correlation between the markets, aiming to highlight the best method to capture this aspect.

The study revealed that the Romanian market was little correlated with the Eurozone market in 2001-2006, the level of integration being very low before Romania joined the European Union. Subsequently, this level of integration has increased significantly, with two possible determinants: i) the economic crisis in 2008 that has led to increased correlations in the market; ii) the increase of trade flows between Romania and the Eurozone after the accession to the European Union.

For the other 3 countries (Poland, Hungary and the Czech Republic) a higher correlation level was observed since the beginning of the analysis period (2001), and the dynamics was similar. The correlation with the Eurozone increased significantly during the crisis period and then gradually diminished, but remained slightly higher than in the pre-crisis economic and financial period of 2008. Thus, it can be said that in times of crisis associated with the increase of integration between countries, the principle of diversification does not work any longer, as they move in the same direction. This is useful for portfolio managers, as they can reduce exposures to specific markets because they no longer add value to a portfolio.

Another idea followed by this paper is the difference between rolling-window Pearson Correlation and the DCC-GARCH conditional correlation. It was highlighted that the result obtained by applying DCC-GARCH is more appropriate for the context of managing a diversified portfolio. The DCC-GARCH correlation is more flexible, responds faster to market changes, and provides the portfolio manager with faster market change information compared to the rolling-window Pearson Correlation. Thus, the fund manager could react more quickly and make faster investment decisions in the context of new market realities.

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