ИКОНОМИЧЕСКИ ИЗСЛЕДВАНИЯ
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CRISIS INFLUENCES BETWEEN DEVELOPED AND DEVELOPING CAPITAL MARKETS – THE CASE OF CENTRAL AND EASTERN EUROPEAN COUNTRIES

The study aims to trace the influence between developed and developing capital markets in the context of the Efficient Market Hypothesis, taking into account the global financial crisis of 2008. In the study are used seven indices, two are representing developed markets – the U.S. DJIA, the German DAX and the rest five – developing markets of Central and Eastern Europe (CEE) – Bulgarian SOFIX, Czech PXI, Hungarian BUX, Romanian BET and Russian RTS. Using daily returns from 2005 to 2012, we investigate the volatility co-movement between the U.S. and the German indexes on one side and the CEE indices on another. In order to do so we apply EGARCH model to market data deviated in three periods – Pre-crisis, Crisis and Post-Crisis. In terms of correlation CEE indices can be divided in two – Czech, Hungarian, Romanian and Russian, showing a high correlation with the German index, and Bulgarian SOFIX demonstrating greater synchronicity with the U.S. index. This observation is confirmed for the three periods of study. Examining the volatility co-movement we can point out that the Hungarian, the Czech and the Russian indexes are clearly showing a leading role for their dynamics by the German index, for all studied periods. The Romanian index is showing a hesitating reaction to the deterministic influence of DJIA and DAX. For the Bulgarian index if there is a significant external influence, it is always by the DJIA. Regarding the reaction to the market impulses and information efficiency Bulgarian and Romanian indexes are clearly distinguished from the other studied CEE indexes. They showed disposition for faster and more sensitive reaction to negative market impulses, typical for the Crisis Period, in contrast to a moderate incorporation of the positive market impulses specific to the Pre-crisis Period.
JEL: C 32; G01; G14; G15

1. Introduction

The theme for informational efficiency of capital markets became stronger relevance during the development of the global financial, crisis started in the USA in 2008. Theoretical postulates covering dynamics of capital markets determine the prediction of future changes of the financial assets prices as useless because they accept that the fundamental changes in

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the market are result of new information for it, which information by definition is unknown, because if it is known it will already be included in the market dynamics. These assumptions form the information efficiency of a capital market and they are at the base of the efficient markets hypothesis (EMH). Empirical research market data and some practical techniques showed that there could be some violations of EMH, especially if you take into account their determination as to the level of development of the capital markets. The global financial crisis of 2008 proved its significant impact on all capital markets, in direct contradiction of the theoretical postulates that the correlation between developed and developing markets by default is very low. This revealed a new opportunity not only to check the consistency of one of the basic assumption of capital markets - their information efficiency, reflected by EMH, but also to determine and analyze the informational influence in field of relations developed-developing market.

The main goal of this study is to test the assumption of the EMH that correlation between developed and developing markets by default is very low hence the volatility co-movement is insignificant. And consequently study the following questions:

- Is the existence of this co-movement determined by the presence of the financial crisis of 2008?
- How this co-movement influence on the information efficiency and asymmetry of the studied developing markets?

For realization of this research are used seven indices, two are representing developed markets – the U.S. DJIA, the German DAX and the rest five – developing markets of Central and Eastern Europe (CEE) – Bulgarian SOFIX, Czech PXI, Hungarian BUX, Romanian BET and Russian RTS. Using daily returns from 2005 to 2012, we investigate the volatility co-movement between the U.S. and the German indexes on one side and the CEE indices on another. In order to do so we apply EGARCH model to market data deviated in three periods – Pre-crisis, Crisis and Post-Crisis.

The structure of the research presentation is as follows: Section 2 describes the main theoretical and empirical achievements reflected in the literature on the topic of EMH, its assumptions and violations relating to developed and developing markets. Section 3 reflects the used in the empirical part of the econometric methodology. Section 4 provides an empirical study and interpretation of results. Section 5 generalizes the conclusions and findings of the empirical study.

2. Literature Review

Random walk hypothesis states that prices or returns of the financial assets are independent of each other and changes randomly thus this cannot be predicted from historical data. Unpredictability of the return changes is based on their rationality. Only rational change will be determined as a result of new market information. Therefore, the random walk will be expected result for the dynamics of the index, which always takes into account all available current information (Efficient market hypothesis – EMH). Empirical studies about the developing capital markets present evidence of violations of the assumptions associated with EMH. They provide evidence of their information ineffectiveness, questioning the accuracy of the EMH. Significant levels of inefficiency are observed in the capital markets of India, Singapore, Ghana and Mauritania (Bekaert and Campbell, 2002; Bundoo, 2000; Smith and Jefferis, 2002). Empirical evidence from tests on the hypothesis of a random walk for prices of capital markets in Egypt, Kenya, Morocco and Zimbabwe (Mlambo, Biekpe and Smit, 2003) indicate rejection of the normal distribution assumption of the returns and the presence of positive autocorrelations. Researches made by Koutmos (Koutmos, 1999) about Asian emerging markets showed differences in incorporation of market information, resulting in more faster market incorporation of bad news and respectively negative return. Established by Koutmos circumstances are directly related to the presence of statistically significant autocorrelation of volatility and indirect evidence of leverage effect.

Using a GARCH, EGARCH and GJR models, Balla and Premarante (Bala, Premaratne, 2004) examine the volatility dynamics of Singapore, Hong Kong, Japan, US and UK stock markets over a 10 year period. Generally, it was found that asymmetry is significant and supported in all five markets. Shocks to the Singapore market tends to linger around for a longer period than it does in other stock markets. This may imply that the Singapore shows less market efficiency than the other markets as the effects of the shocks take a longer time to dissipate.

Study, that covered four of the most popular index of the Egyptian Stock Exchange showed a significant deviation from EMH (Mecagni and Sourial, 1999). Expressions of this inefficiency are the observed volatility clustering and high kurtosis distribution of returns. Evidence of violation of the EMH can be found at Serbia's capital market. In the study conducted by Miljković and Radović (Miljković, Radović, 2006) are presented evidence that the Serbian stock market does not show efficiency even in the weak-form of EMH. They found statistically significant levels of autocorrelation in returns with high kurtosis distribution, significantly different from the normal. Similar results are recorded for the Central European capital market represented by the daily logarithmic changes in the index CESI – originally published at Budapest Stock Exchange in 1996 and including equity securities from Budapest, Prague and Warsaw stock exchanges (Kanaryan, 2004). The empirically established characteristics of the emerging markets, like type of distribution, statistically significant autocorrelation and the presence of non-linear dependencies, are also valid for some developed capital markets – the Swedish index OMX which includes 30 large companies in Sweden (Nässtrom, 2003).

Maria Borges (Borges, 2010) conducted empirical tests on the weak-form of market efficiency applied to stock market indexes of UK, France, Germany, Spain, Greece and Portugal, from 1993 to 2007. Overall, the results show mixed evidence on the EMH. The hypothesis is rejected on daily data for Portugal and Greece, but these two countries have been approaching martingale behavior after 2003. France and UK data rejects EMH, the tests for Germany and Spain do not allow the rejection of EMH, this last market being the most efficient. A testing for random walks and weak-form market efficiency in European equity markets is done by Worthington and Higgs (Worthington, Higgs, 2004). Daily returns for sixteen developed markets (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom) and four emerging markets (Czech Republic, Hungary, Poland and Russia) are examined for random walks. The results indicate that of the emerging markets only Hungary is characterized by a random walk and hence is weak-form efficient, while in the developed markets only Germany, Ireland, Portugal, Sweden and the United Kingdom comply with the most stringent random walk criteria.

Ali and Afzals (Ali, Afzal, 2012) empirically revealed, by using EGARCH model, that negative shocks have more pronounced impact on the volatility than positive shocks on Pakistani and Indian stock exchanges. These stock markets also demonstrate existents of persistent volatility clustering. Sengonul and Degirmen (Sengonul, Degirmen, 2010) investigated the impact of recent global financial crisis on the weak-form of efficiency of markets of the countries from 2004 enlargement of the European Union, Bulgaria and Romania on the one hand and Turkey on the other hand. The results indicate that Bulgaria, Romania, Estonia, Lithuania, Malta and Slovenia are demonstrating weak-form of market inefficiency both pre-crisis and post-crises periods. On the other hand, Czech Republic, Cyprus and Latvia clearly departed from weak-form of efficiency after the crisis. Among the studied countries, Hungary, Slovakia and Turkey performed better. Among three of them, Hungary appeared the best efficient while Slovakia and Turkey follow her with slight departing from efficiency. Abdmoulah (Abdmoulah, 2009) uses GARCH-M (1.1) approach to test weak-form of efficiency for 11 Arab stock markets for periods ending in March 2009. All markets show high sensitivity to the past shocks and are found to be weak-form inefficient, as negatively reacts to contemporaneous crises. Mishra (Mishra, 2011) study the impact of recent global financial crisis on the weak form of EMH in the context of select emerging and developed capital markets – BOVESPA of Brazil, SENSEX of India, Shanghai Composite Index of China, KOSPI Composite Index of South Korea, RTS of Russia, NASDAQ Composite of US, DAX of Germany and FTSE 100 of UK for the period 2007 to 2010. The used ADF unit root test and GARCH model estimation provides the evidence that the selected capital markets are not weak-form efficient. However, such informational inefficiency of capital markets often provides the impetus for successful financial innovation by financial firms thereby making the market move towards efficiency in the long run.

3. Methodology

The study aims to trace the influence of the informational links between developed and developing capital market in the context of the Efficient Market Hypothesis, taking into account the importance of specific factors – the global financial crisis of 2008. Reflecting the initial manifestation of that factor we focus our searches on the line developed market – DJIA to following coverage of other developed – DAX and developing markets of Central and Eastern Europe (CEE) – BET, BUX, PXI, RTS and SOFIX. Choosing the DJIA is dictated by the fact that this is one of the first U.S. indices, reflecting the dynamics of the major U.S. companies and economy in general. The index still retains its meaning of a key indicator of U.S. stock trading. It should be noted also that DJIA is a price weighted index thus it shows most high sensitivity to the fluctuation of the prices of shares as a result of market information, especially during the crisis situation. Aspect that we find important in the analysis of the volatility of returns of the markets surveyed. The inclusion of the DAX index is inspired by the fact that it represents the most important and with the highest GDP economy of continental Europe, which is a major exporter internationally and thus relatively sensitive to dynamic processes in economic activity globally.

The data used in this study include daily values of the analyzed CEE indices, DAX and DJIA, for the period 03.01.2005 – 30.12.2011 and received on their return based on the formula $r_t = \log\left({I_t}/{I_{t-1}} \right)$, where I_t is the value of an index for the t day. The period is divided into three sub-periods of the following duration: Period 1 - from 04.01.2005 until 22.12.2006, Period 2 - from 02.01.2007 until 28.12.2009 and Period 3 – from 04.01.2010 until 30.12.2011. Total of 12,257 observations were used (Period 1 – 3507, Period 2 – 5214 and for the Period 3 – 3536). Conditional the three periods can be defined as pre-crisis (Period 1), crisis (Period 2) and post-crisis (Period 3). Differentiation between period 1 and 2 is made at the beginning of 2007 due to the different moments of reflecting of the financial crisis on the studied markets. This required separation between the two periods of study to be applied to the beginning of 2007, so the influence of 2007's financial crisis to be fully incorporated, including the period immediately before the initial manifestation and reached bottom, taking into account the time lag required for the coverage of U.S. into the European market in its two forms, shown in this study – developed (Germany) and revolves market (indexes surveyed CEE).

To achieve compatibility between daily returns data of the studied CEE indices and data from the DAX and DJIA, from daily returns of U.S. and German indices were removed data for the days that were non trading (holiday) for relevant CEE capital market. Also for the days that have been trading for the stock market in CEE, but not for the U.S. and the German stock market we use data for the last trading day of the DJIA and DAX. This is done with the understanding that the information content and hence impact of studied developed capital markets to those of CEE is expressed in the last value of the DJIA, respectively, DAX, which in this case is a constant for the trading days in the CEE markets in terms of missing trade of a developed capital market. Thus, the number of observations for each studied period is equal for the corresponding CEE index and the DJIA and DAX.

Given that markets analyzed are positioned in a large geographic scale we have to consider factor like time zones and its impact on the accuracy of econometric modeling. While functioning in different time zones there is an interval of time in which all of studied capital markets operate at moment t accumulating information and make information exchange with each other. It should be noted that European markets are closing before the U.S. and so they have the opportunity to incorporate DJIA's dynamics in their closing index values, namely closing values are those used in this study. The U.S. market continues to accumulate informational content after the European markets are closed, this information can't be reflected in moment t for them, but in moment $t+1$ and following moments. Assuming that due to the time zones only part of the information content at the moment t of the U.S. market reflects at the same time on the European markets and the rest in the next lag $t+1$, then at some moment t the European indices will reflect both current information from DJIA and the information content of the lag $t-1$. The latter reflects the past DJIA index value which is covered by econometric modeling of returns and volatility and included in correlation analysis. Used DJIA values for the econometric models are in dimension reflecting past ten lags back to moment t and as such we can assume that they fully represent the informational influence on European indexes.

The establishment of direct relations between the return values of the studied indices we can achieve by determining the correlation between them. Presuming deterministic influence of U.S. index we represent and analyze correlation of returns between values at the moment t for studied CEE indices and values for ten lags back of DJIA and DAX.

To identify and measure the influence of the DJIA and DAX index on studied CEE indices, will be used the model of returns from studied CEE index expanded by an additional member reflecting successive returns of the indices DJIA and DAX. In terms of volatility will be used exponential generalized autoregressive conditional heteroskedasticity model – EGARCH (Nelson (1991)) with Student t – distribution. The benefits of this model application are presented and advocated in many empirical studies from which should point those of Nelson (Nelson, 1989, 1991), and Pagan and Schwert (Pagan and Schwert, 1990) and Hentschel (Hentschel, 1995).

Used model of returns is as follows:

$$Y_t = C + \phi_1 Y_{t-1} + \varepsilon_t + \phi_2 X_{t-n}$$

Where:

C - regression constant;

Y_{t-1} - return from the studied CEE index at the moment $t-1$;

ϕ_1 и ϕ_2 - regression coefficients;

X_{t-n} - return from DJIA or DAX in dimension $t-n$ which represent the lag that achieves the highest levels of correlation with the studied CEE index.

The used EGARCH (p , q) model represents the conditional volatility of residuals ε_t with the respect of leverage effect:

$$\log h_t^2 = \alpha_0 + \sum_{i=1}^{P} \beta_i \log h_{t-i}^2 + \sum_{j=1}^{Q} \alpha_j \left[\frac{|\varepsilon_{t-j}|}{h_{t-j}} - E\left\{ \frac{|\varepsilon_{t-j}|}{h_{t-j}} \right\} \right] + \sum_{j=1}^{Q} \gamma_j \left(\frac{\varepsilon_{t-j}}{h_{t-j}} \right)$$

Where:

$$E\left\{\left|z_{t-j}\right|\right\} = E\left(\frac{\left|\varepsilon_{t-j}\right|}{h_{t-j}}\right) = \sqrt{\frac{\nu-2}{\pi}}\,\frac{\Gamma\left(\frac{\nu-1}{2}\right)}{\Gamma\left(\frac{\nu}{2}\right)}$$

With degree of freedom $\nu > 2$.

The information efficiency as an indicator of performance will be determined by the magnitude of the coefficient of persistence, representing the impact of tendencies from prior periods on the volatility in the present period. In the asymmetric EGARCH (p , q) model coefficient of persistence is represented by the coefficient – β_i. High values of this coefficient would indicate a low informational efficiency, reflected in slower incorporation of the market information because of a higher influence of the market volatility tendencies and opposite for lower values of the coefficient of persistence. The definition of information efficiency is made according to the efficient markets hypothesis (EMH). The measurement of information asymmetry as an indicator, i.e. measurement of asymmetric adjustment of the EGARCH (p , q) model, is implemented and measured by the coefficient γ_j. The analysis of these values can specifically measure the impact on the volatility of different informational impact and make conclusions about asymmetric volatility adjustments to them. Have to emphasize that the formulation of the notion of information asymmetry is made in terms of the approved methodology based on econometric models such as GARCH and EGARCH, formulation established as by the authors of these econometric models and also by numerous empirical studies reflecting their use. For this reason for used in this study econometric models we consider the term information asymmetry as a measure of the different as a sign and power influence of market information causing positive or negative change in returns and volatility of an index. This way it is possible to assess the varying in sign and size response of studied markets to the different information influences on it.

The selection of values p and q for used EGARCH models is based on testing different combinations of values by applying the Akaike information criteria (AIC) test. The output combinations of parameters p and q are determined by the maximum value of 2 for both parameters and thus tested are the following combinations: (1,1), (2,1), (1,2) and (2,2).

The selection procedure seeks a combination of the two parameters that leads to more successful modeling of the studied data. Perception of this can be gain by comparing the extent to which different combination of the two parameters for the equation of volatility adequately model the input data for the studied period. For the AIC test as input are used values of the log-likelihood objective function – LLF calculated for each specification p and q separately. Depending on the distribution used for estimation of the EGARCH models following forms of LLF are used:

- Normal distribution

$$LLF = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log\sigma_t^2 - \frac{1}{2}\sum_{t=1}^{T}\varepsilon_t^2\sigma_t^2$$

- Student t - distribution

$$LLF = T\log\left\{\frac{\Gamma\left[\frac{(v+1)}{2}\right]}{\pi^{\frac{1}{2}}\Gamma\left(\frac{v}{2}\right)}\left(v-2^{-\frac{1}{2}}\right)\right\} - \frac{1}{2}\sum_{t=1}^{T}\log\sigma_t^2 - \frac{v+1}{2}\sum_{t=1}^{T}\log\left[1+\frac{\varepsilon_t^2}{\sigma_t^2(v-2)}\right]$$

The reason not to use only normal distribution lies in its third and fourth central moments. Empirical studies show that financial data indicate distributions characterized by asymmetry and kurtosis whose values differ from the eligible for normal distribution. To reflect typical for the capital markets high kurtosis distributions with so-called "fat tails" in econometric researches are commonly used distributions other than normal. In this study, we use normal and Student-t distribution.

The LLF is a function of the procedures based on maximum likelihood for estimation of the parameters of used EGARCH models and as such, it reflects the extent to which the model of conditional return and EGARCH adequately modeling the input data. Because of that LLF can be used by AIC test as criteria for selecting between competing models.

4. Empirical data

4.1. Correlation

Based on recorded and presented in tables 1, 2, 3 and 4 values of correlation of the studied indices can draw the following conclusions determined from each period of study.

<u>For the Pre-crisis Period 1</u>

1. All indices without SOFIX, BET and RTS to DJIA experiencing relatively high levels of correlation with the DJIA and DAX (see Tables 1 and 4), the general trend of the high correlation is achieved through the low lags (t, $t-1$ and $t-4$) and reaches the lowest value at relatively high correlation lags (6, 7, 9 and 10). This indicates a high degree of informational efficiency of CEE indices toward developed markets, the information is incorporated at the time of its formation (t and $t-1$) and has an impact for a long period until it exhausts its importance in information lags 6 to 10. We can determine that when a positive market trend is present CEE markets tend to form and follow a long-term trend, in line with the positive news from the developed markets.

Exception from this general trend is made by the Romanian index BET, demonstrating a relatively low correlation with the DJIA and DAX, the highest correlation is achieved through the low lags ($t-1$ and $t-4$), and lowest for lags $t-7$ and $t-9$. This means that the information is incorporated at the time of its formation (t and $t-1$), but its full coverage requires lengthy period of incorporation - to lag $t-9$. The index SOFIX differs from other indices by his approach toward correlation, the dynamics of which shows not only a lack of high influence of the DJIA and DAX indices, but completely opposite reaction to the information from them. Preceding the highest negative values of correlation (lags t and $t-3$) followed by the highest positive (lag $t-5$ for both indexes) showed weaker information efficiency leading to a need of relatively long time for the positive market impulses form developed markets to make significant formative influence, add to this the relatively low values of correlation and we can outline a very low impact on SOFIX from developed markets in an upswing of Bulgarian market.

2. It is evident that many of the CEE indices marked a correlation dominance of DAX in compared to DJIA. The values of correlation between CEE indices and DAX, DJIA ranged from 0,3364 to 0,4402 - from a statistical point of view, they did not mark marked a high correlation, but it should be borne in mind that they reflect the values of the linear correlation, which does not cover non-linear one, thus interconnection between studied indices may be considerably higher. While in their relative content these correlation values mark tendencies. Should distinguish SOFIX, which takes into account a significant impact on part of the U.S. index, but the correlation value recorded was lower than shown by other indices, so we can look at relatively high degree of independence of the Bulgarian index from DJIA and DAX in the conditions of rising market.

<u>For Crisis Period 2</u>

1. All indices studied showed identical behavior towards efficiency against DJIA and DAX. Maximum values of correlation are registered in the interval t to $t-1$ and reached minimal values in lags 2 to 4. This observation leads us to conclusion that in times of crisis studied indices has significantly greater informational efficiency vis-a-vis developed capital markets, the new information will be incorporated as soon as possible after its occurrence and shall be implemented in full after only a few lags. An exception to this we find only at BET to DAX, where the minimum value of correlation was observed in lag 10.

2. Identical to the Period 1 all CEE indices during Crisis Period 2 showed significantly greater synchronicity with dynamic of DAX rather than DJIA. Registered maximum values are positively correlated in the range 0.5537 to 0.6460, which is significantly higher compared to the U.S. index registered – from 0.4009 to 0.4142. Although the general trend is shown by index BET, which unlike the first period shows higher synchronicity with the German DAX than with DJIA, the values of the correlation is

relatively low in comparison to other CEE indexes (0.1908 to DAX and 0.1416 to DJIA).

3. During the Crisis Period 2 the Bulgarian index SOFIX shows interconnection and dynamics, which is opposite to that demonstrate by other studied CEE indexes. Established a high degree of correlation with the U.S. index DJIA, as compared to the German index, but in absolute terms it is considerably lower than the range of the correlation between DAX and CEE index – 0.3851 between SOFIX and DJIA comparing to the interval of 0.5537 to 0.6460 for the CEE indices to DAX.

<u>For the post-crisis Period 3</u>

1. It is noteworthy that from three periods studied particularly in the post-crisis period we find the highest values of correlation between the CEE indices, DJIA and DAX. In all the studied indices recorded a relatively high increase in correlations, the drop was only apparent at PIX to DAX, also SOFIX to DJIA and DAX, but considering the relatively low rates of downward rather we could talk about preserving the correlations from Crisis Period 2. For increase strength of the correlation of CEE indices we can judge by the extent of the range of their expression – from 0.2386 to 0.7027 for the DAX and from 0.3107 to 0.5726 for the DJIA. These intervals for Crisis Period 2 are respectively – from 0.1908 to 0.6460 for the DAX and 0.0523 to 0.4142 for the DJIA.
2. Like in Period 2 in pre-crisis Period 3 almost all CEE indexes show higher correlation to DAX rather than to DJIA. The most powerful is this dependence on Russian RTS (0.7027) followed by the Hungarian BUX (0.6432), Czech PXI (0.6367), Romanian BET (0.4509) and Bulgarian SOFIX (0.2386). Bulgarian index should be indicated by the fact that he is the only one of the studied CEE indices who in crisis and in post-crisis period continues to demonstrate a highest correlation to the DJIA, the change in the magnitude of the correlation coefficient between those two periods is very low – from 0.3851 (Period 2) 0.3224 (Period 3).
3. Summarizing the results based on correlations coefficients for Period 3 we can make the following conclusions: in a post-crisis recovery in CEE indices studied showed still greater degree of synchronicity in their dynamics with that of developed markets which began the transfer of crisis influences onset of the global financial crisis of 2007. From all surveyed CEE indices only Bulgarian SOFIX shows relative constancy in correlations against the DJIA and DAX, while maintaining a leading position in this regard for DJIA, in the trend established by the Crisis Period 2.

In the process of identifying and analyzing the interaction between the studied CEE indices and developed capital markets represented by indices DAX and DJIA came the question of his strength against the recorded values of correlation coefficients. Assuming value of the coefficient of at least 0.5 as the threshold of a significant correlation, then, during the Pre-crisis Period 1 all the CEE indexes and some of them in the Crisis Period 2 (BUX and DJIA, PXI and DJIA, as well as in BET and SOFIX to DJIA and DAX), gives us no reason to determine that there is a high degree of correlation between the Bulgarian, Romanian, Russian, Czech and Hungarian indices and DAX or DJIA. Similar is the situation in Post-crisis Period 3, most of fluctuation of the values of correlation coefficients are about the limit of 0.5.

These results can be interpreted, when attributed to the nature of the correlation coefficient, which is based on the Pearson correlation coefficient, suggesting a linear relationship between two variables. In this case, the correlation coefficient would be a useful indicator of the relationship between the two indices, but if their relationship is nonlinear, then he would not be able to fully comprehend. This leads to a situation where the correlation coefficient showed low values, but in fact the relationship is greater between the two indices. This can be explained by the presence of nonlinear relationships that Pearson's coefficient is not reported.

4.2. Nonlinear dependencies and GARCH effects

Non-linear, if available would refute the idea of a random walk in the prices of financial assets under the efficient markets hypothesis and would define market informational efficiency as weak. Implemented in this study to verify the presence of nonlinear dependence in volatility is achieved by considering the autoregression of the residuals ε_t from the model of return, which applies Engle ARCH test (Engle, 1982). Results of these tests (see Table 5) allow us to reject the null hypothesis, which suggests that all ε_t are independent and identically normally distributed with $N\left(0,\sigma^2\right)$, i.e. no correlation between the residuals exists. Empirically established presence of ARCH - effects directly shows the existence of nonlinear relationships between values of volatility and the return of the surveyed CEE indices. Objectivity insists to consider the absence of ARCH effects for lags 1 and 2 for the BUX index for Period 1, a fact that renders the use of GARCH models for that index, period and lags.

Identification of nonlinear relationships is important because the simplest known form of non-linearity in econometrics is that which occurs when the observed variables in a linear regression model is transformed so as to take into account first order autoregression of the residuals ε_t. This is accomplished through the use of models from the type of generalized autoregressive conditional heteroskedasticity – GARCH. Thus, testing for the presence of nonlinear relationships could be seen as testing the suitability of a financial data modeling using GARCH models, particularly those used for this study EGARCH model.

4.3. Application and calculation of EGARCH models

<u>4.3.1. Determining the optimal size of lags and EGARCH models</u>

To determine the amount of lags p and q we are using Akaike (AIC) information criteria test. Under his administration should be recognized that it is adversely affected by a large number of parameters in the tested models and this gives an advantage in comparison to those with fewer ones. For these tests are used as input parameters of the LLF values and the number of parameters of tested EGARCH models used for its calculation. The relationship between the value of the LLF and the number of parameters defines the test statistics that serve as criteria for comparison between competing models. It is the model with the smallest value of a test statistic is preferable. Finally selected models with lags p and q are tested with normal distribution and with Student t-distribution to determine the best fit.

The results of the AIC test for the studied indexes, periods and test statistics are presented in Table 6. From these data we can conclude that the most successful modeling inputs for the return of the studied indices give us the following combinations of lags p and q for used in this study EGARCH models:

1. For BET
   - Period 1 – EGARCH (2.2) – t - distribution
   - Period 2 – EGARCH (1.1) – t - distribution
   - Period 3 – EGARCH (1.2) – t - distribution
2. For BUX
   - Period 2 – EGARCH (1.1) – t - distribution
   - Period 3 – EGARCH (2.1) – t - distribution
3. For PXI
   - Period 1 – EGARCH (2.2) – t - distribution
   - Period 2 – EGARCH (1.2) – t - distribution
   - Period 3 – EGARCH (1.2) – t - distribution
4. For RTS
   - Period 1 – EGARCH (1.2) – t - distribution
   - Period 2 – EGARCH (1.1) – t - distribution
   - Period 3 – EGARCH (2.2) – t - distribution
5. For SOFIX
   - Period 1 – EGARCH (2.2) – t - distribution
   - Period 2 – EGARCH (2.2) – t - distribution
   - Period 3 – EGARCH (1.1) – t - distribution

Objectivity insists to make the following comments on the test results for the Czech index PXI and Period 3. Although formally a lower AIC test statistics is for model with normal distribution we adopt the model with Student t - distribution. Relatively very close values of AIC test statistics for compared models and as a result of a subsequent measurement of AIC test statistics for EGRACH model with data from PXI and from DJIA and DAX indices, conclusively establish the superiority of EGRACH models using t-distribution and their results will be used as representative data from the index PXI.

The dimension of final selected lags p and q can outline an initial indication of the informational efficiency of studied CEE indices. For the pre-crisis Period 1 final selected models are tested with maximum dimensions of lags p and q for two lags behind. This result for the CEE indices can be explained by the fact that on the dynamics of these indices take affect available autocorrelation and external dependencies determine market reaction manifested in the slow incorporation of market information in index values and consequently need in econometric modeling to be used data for more than one lag behind.

For Crisis Period 2 the results for the CEE indices show the dimension of p and q near one lag, thus marked lack of longer-term trends in autocorrelation and increased following the current at the moment t market dynamic. An exception in this respect is the registered index SOFIX – EGARCH (2,2), which is the first one indication of that in the Crisis Period 2 Bulgarian index shows a high tendency to follow negative market fluctuations than other studied CEE indices.

In the post-crisis Period 3, we cannot clearly identify a general trend in determining the dimensionality of p and q. The situation is more clearly stated only for indices SOFIX – EGARCH (1.1) and RTS – EGARCH (2.2). These two examples show the opposite effects of the incorporation of market information in a post-crisis market. Bulgarian index, unlike the Crisis Period 2, shows a lack of longer-term direction of the market dynamics and adherence to the current market situation at the moment t. Opposite is the reaction of the Russian index showing a stronger tendency to follow the post-crisis market trends and sustainably incorporating them in the index values.

Another important result is that all the selected models use Student t- distribution, with which confirm established by numerous empirical studies on the capital markets fact of existence of high kurtosis distributions with so-called fat tails in the return of capital markets regardless of their level of development.

4.3.2. Calculation of selected EGARCH models

4.3.2.1. Calculation of selected EGARCH models with data from the CEE indices and without DJIA and DAX

The analysis of the values of the coefficients of persistence (Persistence) – β_i and leverage – γ_i for EGARCH models with data from CEE indices and not including indices DJIA and DAX can help us determine informational efficiency and asymmetry related to studied CEE indices.

The values of the coefficient of persistence and related informational efficiency show distinct clustering of the studied indices based on their reaction to the information entering the market. In a group with identical market reaction can include indexes BUX, PXI and RTS and with opposite in informational aspect behavior can be distinguished from the other group composed by SOFIX and BET. The Bulgarian and Romanian indexes show disposition for faster and stronger react to negative news, typical for crisis Period 2, in contrast of demonstrated moderate response to the incorporation of positive market news typical pre-crisis Period 1. This type of market reaction is the opposite of behavior shown by other CEE indices witch follow a sustainable market trends during Period 1 and give much lower significance of the new information to the market in comparison with following the longer-term trends. This type of market behavior turns during Crisis Period 2 and shows an enhanced response only to short-term market fluctuations rather than follow a relatively long-term market trends. In the post-crisis Period 3 the clustering of the studied indices remained, as for SOFIX and BET, albeit in a limited degree they return to more moderate and short-term following of market trends, as opposed to other CEE indices that indicate predisposition to formation and following of longer-term market trends.

Data on dynamics of coefficients of persistence from one period to another (tables 7 to 11) are as follows:

1) *From Period 1 to Period 2:*

- For BET from 0.9905 to 0.87823;
- For BUX from 0.93204 to 0.98247;
- For PXI from 0.866275 to 0.97016;
- For RTS from 0.92944 to 0.99;
- For SOFIX from 0.99786 to 0.84682.

2) *From Period 2 to Period 3:*

- For BET from 0.87823 to 0.96468;
- For BUX from 0.98247 to 0.95057;
- For PXI from 0.97016 to 0.9734;
- For RTS from 0.99 to 0.98098;
- For SOFIX from 0.84682 to 0.85591.

It is worth noting that the coefficient of persistence of SOFIX showing the highest degree of fluctuation from a single period to another. The data show the following fluctuation – from 0.99786 to 0.84682 and 0.85591 – which is the largest decrease in the coefficient of persistence for all CEE indices. This can be interpreted on a base of comparison with BUX, PXI and RTS indexes, which shows decreasing in their informational efficiency switching from pre-crisis to crisis period, resulting in a short-term following the crisis market trends. In this respect SOFIX demonstrates the opposite reaction for increased informational efficiency, leading to much stronger respond to negative crisis information, resulting in advance incorporation of market information in the values of return from SOFIX during crisis Period 2 compared to pre-crisis Period 1. We can determine that the reaction on the market information in Period 2 is so accelerated that when it becomes publicly available at the moment t most of the content is already included in the values of SOFIX under the form of followed strong market trends.

To determine and analyze the presence of information asymmetry associated with the degree of response of volatility of CEE indices to positive and negative market news we must consider leverage coefficients (γ_1 and γ_2) from EGARCH models unreported returns on DJIA and DAX.

Data on dynamics of leverage coefficients (γ_1 and γ_2) from one period to another (Tables 7 to 11) are as follows:

1) *From Period 1 to Period 2:*

- For BET from -0.00496 to -0.093246;
- For BUX from -0.033055 to -0.06608;
- For PXI from -0.21168 to -0.069144;
- For RTS from -0.058573 to -0.074087;
- For SOFIX from 0.006795 to -0.10257.

2) *From Period 2 to Period 3:*

- For BET from -0.093246 to -0.079222;
- For BUX from -0.06608 to -0.13004;
- For PXI from -0.069144 to -0.07877;
- For RTS from -0.074087 to -0.05556;
- For SOFIX from -0.10257 to -0.040722.

Analysis of the data allows us to draw the following conclusions:

1. Indices BET, BUX, RTS and SOFIX increase their absolute values of leverage coefficients during Crisis Period 2. Thus, we can determine that information asymmetry for those indices defines a stronger reaction to negative market news, giving them a greater weight in the equation of volatility compared with Pre-crisis Period 1 with predominantly positive information impulses. Also recognizing the sign of coefficients, we can determine that during the crisis period negative news have a greater weight, leading to a large increase in volatility, and vice versa, during the Pre-crisis Period 1 negative sign of leverage coefficients leads to a reduction of volatility, but this correction is lesser extent as compared to Period 2.
2. The PXI index showed the opposite response of his information asymmetry established on the basis of his leverage coefficients. Observed from Period 1 to Period 2 reduction

in the value of leverage coefficient while maintaining a negative sign leads to the conclusion that during the crisis negative impulses PXI index show a weaker response and low increasing its volatility. Continuing analysis to the value of information asymmetry for Period 1, we see that PXI index strongly follows market tendency only when we have a growing market trend (Period 1), leading to a strong positive reaction to market information and greater reduction in volatility. In times of crisis (Period 2) and negative information impulses PXI index shows a weaker response to market information, do not form and follow relatively long-term trends and show a slight increase in volatility.

3. In the Post-crisis Period 3 dynamics of leverage coefficients shows grouping of the studied indices according to the correction of their information asymmetry. The first group consists of indices BET, RTS and SOFIX observed post-crisis "cushion" of information asymmetry manifested as a decrease in the strength of response to market information and hence reduction in the volatility of the markets surveyed. The reported decrease in leverage coefficients can be seen as a return to the situation of information asymmetry for Pre-crisis Period 1 in which the dynamics of market information has less impact on volatility than during the Crisis Period 2. Taking into account a negative sign leverage coefficients in the Post-crisis Period 3, the prevailing positive market dynamics reduces the volatility of indices. We should also note the fact that, except for RTS index, levels of lowered leverage coefficients are higher than Pre-crisis Period 1 which can be considered as potential for more significant change in volatility in the occurrence of negative market news compared to Period 1.

The other group consists of the Hungarian BUX and Czech PXI, in which registered an increase of leverage coefficients from Crisis Period 2 to Post-crisis Period 3. This increase – relatively low for PXI and significant for the Hungarian BUX – marked some faster recovery leading to that positive market impulses produce the highest of all studied indices decrease in the volatility of returns on those markets. However, this result must be interpreted with caution because the emergence of negative market impulses with these high leverage coefficients would lead to the strongest of all studied indices increase in volatility.

Summarizing for the informational asymmetry of all studied indices we could point out that they show a weakening of the variability of their returns, but markets surveyed remain elevated potential for relatively strong reaction in the emergence of negative market impulses compared to the pre-crisis period.

4.3.2.2. Calculation of the selected EGARCH models with data from the CEE indices and including as explanatory variables DAX or DJIA

To identify and measure the specific impact of the DJIA and DAX for CEE indices, we will use the model of return applied to the data from each of the CEE indices extended with additional member reflecting successive returns of the indices DJIA and DAX. Based on AIC test results we selected for any one of CEE indices and studied period an EGARCH model which includes DJIA or DAX and by that leads to increase in explanatory power of the model (see Tables from 7 to 11):

1) Pre-crisis Period 1:

- For BET – EGARCH model without DAX и DJIA;
- For PXI – EGARCH model including DAX;
- For RTS – EGARCH model including DAX;
- For SOFIX – EGARCH model without DAX и DJIA.

2) Crisis Period 2:

- For BET – EGARCH model including DJIA;
- For BUX – EGARCH model including DAX;
- For PXI – EGARCH model including DAX;
- For RTS – EGARCH model including DAX;
- For SOFIX – EGARCH model including DJIA.

3) Post-crisis Period 3:

- For BET – EGARCH model including DAX;
- For BUX – EGARCH model including DAX;
- For PXI – EGARCH model including DAX;
- For RTS – EGARCH model including DAX;
- For SOFIX – EGARCH model including DJIA.

Based on data from selected EGARCH models take into account the influence of the DJIA and DAX we can draw the following conclusions:

1. There is a clear distinction of the studied indices into two groups according to deterministic effects of DJIA and DAX. The first covers BUX, PXI and RTS shows clearly determined role for their dynamics of the German index DAX, whether for Pre, Crisis or Post-crisis period. The second group includes Romanian index BET and Bulgarian index SOFIX showing a hesitant reaction to the deterministic influence of the DJIA and DAX, as when significant influence on the Bulgarian SOFIX is present it is always by the DJIA (Crisis Period 2 and Post-crisis Period 3).
2. Using in the model of the return from the BUX, PXI and RTS indexes an additional member reflecting returns from DAX leads to increase its explanatory power for all three periods of study. It should be noted that data from AIC test statistics provide a significant advantage as an explanatory variable for DAX rather than DJIA, especially during the Crisis Period 2:

- *For the Period 1 (DJIA against DAX):*
  - PXI-3.2558e +003 to-3.2578e +003
  - RTS-2.7860e +003 to-2.8372e +003
- *In Period 2 (DJIA against DAX):*
  - BUX-4.0041e +003 to-4.2573e +003
  - PXI-4.1456e +003 to-4.3715e +003
  - RTS-3.5479e +003 to-3.8200e +003
- *For Period 3 (DJIA against DAX):*
  - BUX-2.7721e +003 to-2.9815e +003
  - PXI-3.1396e +003 to-3.2137e +003
  - RTS-2.8438e +003 to-2.9563e +003

3. Using the model of return from SOFIX and BET for Period 2 and 3 with an additional member reflecting returns from DAX and DJIA leads to increase of its explanatory power. At Crisis Period 2 both indices showing greater deterministic influence of the DJIA, while in the Post-crisis Period 3 SOFIX retains its dependence on the DJIA, but for BET deterministic influence came from DAX. For both indices at the Pre-crisis Period 1 AIC test statistics does not give preference to models using DAX and DJIA as an explanatory variable.

For the CEE indices studied inclusion in their EGARCH models of data from DJIA and DAX leads to a correction in coefficients of persistence and leverage. Consider this observation as evidence of informational effects of the DAX and DJIA and its absorption in the values of the indices studied as the correction in coefficients of persistence is the result of an amended information efficiency, i.e. change the extent and intensity of the inclusion of new information in the index. Measurement of this information influence on the volatility of the studied indices is related to the determination of information asymmetries. It was here that reveals the relativity of this asymmetry by relativity of correction in econometric model coefficients that reflect it. Correction that can be defined by the different values of these coefficients for the different information content effects, as presented above, and in terms of correction caused by participation in the econometric models of return data from DJIA and DAX.

Considering the correction in coefficients of persistence and leverage caused by participation in the econometric models of CEE indices of return data from DJIA and DAX we can make the following observations:

1. *For indices BUX, PXI and RTS:*

1.1. The inclusion in the model of return on BUX, PXI and RTS as explaining variable data from the DAX leads to adjustment in their information efficiency attributable to the impact of the German index. For PXI and RTS indices, an increase followed by a decrease in coefficients of persistence in the transition from Period 1 to Period 2 and 3, respectively, a decrease followed by an increase in informational efficiency of PXI and RTS switching from Crisis to Post-crisis market. Taking into account these observations, correlation coefficients between PXI, RTS and DAX, and based on the results from EGARCH models including DAX we can determine more clearly the mechanisms of information impact on PXI and RTS. Inclusion of the dynamics of DAX returns as explanatory variables for these two indices give us the opportunity to determine by the size of coefficients of persistence the degree of information efficiency of PXI and RTS determined by other then German index factors. Observed reduction in information efficiency during Periods 1 and 2 does not mean that the DAX has less impact on PXI and RTS as opposed to the established correlations, but rather is related to the reflection of the strong influence of the sum other factors such as the presence of strong and relatively long-term market trends - a situation very typical of a crisis, influence of other capital markets, etc. Factors, witch combined effect can lead to the formation of a solid trading trend. For significant effects of DAX to PXI and RTS we can judge in Period 3, where inclusion of the German index decreases the coefficient of persistence and increase information efficiency. Increased information efficiency of PXI and RTS shows that in the post-crisis market dynamics of the two indices by a considerable extent is determined by the dynamics of DAX and generally follows a stronger post-crisis trend of development. In this respect, the analysis should consider the performance of Hungarian index BUX. Inclusion of DAX in the BUX's EGARCH model registered opposite change in coefficients of persistence than shown by PXI and RTS, namely the decrease in Crisis Period 2 and increase in Post-crisis Period 3. It should be noted that the close values of the correlation coefficients of BUX, PXI and RTS to DAX, definitely put the Hungarian index in one group with Czech and Russian as the relation to DAX, the difference comes from the different mechanisms by which this relation is realized in the market dynamics of these CEE indices. During the crisis period the market dynamics of Hungarian index is mainly considering the dynamics of DAX, so its inclusion in the BUX's EGARCH model reduces the coefficient of persistence with which shows that the main variable determining the information effectiveness of BUX is precisely the German index and other factors that may affect receive less weight in the equation of the volatility of the Hungarian index. The situation changed radically in the Post-crisis Period 3, where the decline in information efficiency of BUX is marking a strong predisposition to follow the main trends of short-term market dynamics. Such behavior in a post-crisis period can be directed to the existence of a recovering market with more risky potential in which market recovery processes do not form a long-term trend, and give greater weight to short-term market fluctuations.

1.2. The changes in the leverage coefficients of the indices BUX, PXI and RTS due to the inclusion of DAX as explanatory variables are as follows:

- Pre-crisis Period 1

  1 . For PIX from -0.21168 to -0.065802

  2. For RTS from -0.058573 to -0.03354

- Crisis Period 2

  1. For BUX from -0.06608 to -0.057175

2. For PIX from -0.069144 to -0.03187
3. For RTS from -0.074087 to -0.061516

- Post-crisis Period 3
  1. For BUX from -0.13004 to -0.085955
  2. For a PIX from -0.07877 -0.0661309
  3. For RTS from -0.05556 -0.26064

Summarizing we can determine that for the three studied periods we have decreasing in leverage coefficient, explained by the influence of the German index DAX, the exception from the general trend is only RTS for Post-crisis Period 3. Since the observed reduction in leverage coefficients is a consequence of inclusion in EGARCH models of CEE indices of DAX, then we can assume that the amount of this reduction can be seen as part of the information asymmetry of given index directly attributable to the dynamics the DAX. The largest decline in rates, showing the biggest influence on the German index can be presented in following sequence: for Pre-crisis Period 1 – the PXI index (from -0.21168 to -0.065802), for Crisis Period 2 – the PXI index (from -0.069144 to – 0.03187) and for Post-crisis Period 3 – the BUX index (-0.13004 to -0.085955). These data indicate that during the pre-crisis and crisis period the magnitude of response of the Czech index to market information is defined by the highest degree from the dynamics of DAX compared to other CEE indices. During the Post-crisis Period 3 the Hungarian BUX index showed the strongest response to market information in line with the German index. This fact could also be considered by taking into account the informational efficiency of the BUX for the same period indicating a predisposition towards a stronger pursuit of short-term market fluctuations. So we can conclude that during the post-crisis recovering the Hungarian index shows a stronger inclination to follow short-term fluctuations, giving the most significant of all studied indices dependence of market information from DAX. As far as this market information is positive the BUX will achieve greater reduction of the volatility of the return and hence lead to faster post-crisis recovery, but the situation remains with a high risk potential, since the emergence of negative information signals from the market and mainly from the DAX will increase volatility and instability in the Hungarian market.

Exception to the downward trend of the leverage coefficients demonstrate Russian RTS index for the Post-crisis Period 3, the correction is the biggest in comparison to other studied indexes – from -0.05556 to -0.26064. The explanation of that should take into account also relatively very low rate of persistence of the Russian index for this period and show the highest correlation with DAX compared to other studied indices. We can conclude that the Russian index in his post-crisis recovery showed very strong reaction to the positive market impulses, and in this respect RTS formed and followed a very strong market trend, which reflects in a significant degree market dynamics of DAX. Thus, the available positive market impulses lead to significant reduction in the volatility of returns from Russian index. But like the Hungarian index BUX, this situation is related to increased risk exposure of the Russian index since a shift of the positive market impulses with negative well lead to substantial increase in volatility of the market. It should be noted that although their overall higher risk exposure in the post-crisis period, Russian and

Hungarian Index show different reasons for their increased information asymmetry. In BUX enhanced incorporation of positive market impulses can be explained by the dynamics of DAX, while Russian RTS, is driven by its own strong post-crisis trend, which include the dynamics of DAX.

2. BET and indices SOFIX:

2.1. For Period 1 both indices – SOFIX and BET – does not show deterministic influence from DJIA and DAX, both in terms of their information efficiency and asymmetry, and in terms of the volatility of returns, or if such influence exist it is insignificant.

2.2. For Crisis Period 2 including in the model of return of BET and SOFIX as explaining variable return data from DJIA results in an adjustment in their informational efficiency attributable to the impact of the U.S. index. This leads to decrease in coefficients of persistence, which is associated with higher information efficiency. Explanation for these observations is that in a crisis the Bulgarian and Romanian index showed a tendency to form and pursue long-term market trends. In proof of this assertion we can cite the values of the persistence of pre-crisis and crisis period from the models witch not take into account the influence of DJIA and DAX, there is apparent a significant decrease in coefficients of persistence indicate increased information efficiency which leads to greater weight in the dynamics of BET and SOFIX of the long-term trends over short-term fluctuations. The inclusion in the model of returns of BET and SOFIX of the U.S. index leads to strengthening of that tendency to pursue of long-term market trends attributed to the direct reflection of the dynamics of the DJIA. The change in the coefficient of persistence for BET is from 0.87823 to 0.82029 and for SOFIX from 0.84682 to 0.82537, the presented correction is specifically increased information efficiency attributed to the direct influence of the DJIA.

2.3. In the Post-crisis Period 3 the SOFIX and BET indices show differences in the expression of the influence of the DJIA and DAX for their return. Including of DAX as explaining variable for the returns of Romanian index shows shift in a post-crisis recovery while during the Crisis Period 2 greater deterministic influenced for BET was from DJIA. Including of the German index leads to decrease in the coefficient of persistence from 0.96468 to 0.92768 witches indicates increase in information efficiency of BET. This situation is similar to that shown by the PXI and RTS and shows that in post-crisis market conditions BET's dynamics is determined by the dynamics of DAX and the index as a whole is more likely to follow the established post-crisis trend, rather than short-term market fluctuations. We need to pay attention that judging from the achieved levels of coefficients of persistence in Period 2 (0.82029 in DJIA) and Period 3 (0.92768 in DAX) the index in its post-crisis dynamics did not reach the levels of information efficiency typical for crisis period. So we can point out that the stability of following the post-crisis market recovery trend is lower in comparison with which BET followed the negative market dynamics during the Crisis Period 2.

For the index SOFIX we observe preservation of the DJIA index as an explanatory variable, during crisis and in the post-crisis period. About the information efficiency the inclusion of DJIA as explanatory variables for the return of the Bulgarian index leads to relatively very weak correction of coefficient of persistence – from 0.85591 to 0.85311 –

and the corresponding change in information efficiency is very low too. Comparing that data with the change of coefficients of performance persistence for Period 2 (from 0.84682 to 0.82537) we can observe decreasing in information efficiency for SOFIX in terms of the post-crisis market. However, we cannot treat it as an indication of increased risk potential. The explanation comes from the fact that, during the Crisis Period 2 Bulgarian index strongly follows the negative market trend and for short-term market fluctuations is very difficult to divert him from the established sustainable trend. In the Post-crisis Period 3 we observe a weakening of the influence of the relatively long-term market trends and greater weight to short-term fluctuations of the volatility of Bulgarian index.

The changes in the leverage coefficients of the BET and SOFIX indices due to the inclusion of DAX and DJIA as explanatory variables are as follows:

- Crisis Period 2
  - For BET from -0.093246 to -0.12963
  - For SOFIX from -0.10257 to -0.082071
  - Post-crisis Period 3
  - For BET from -0.079222 to -0.107259
  - For SOFIX from -0.040722 to -0.0043931
  - The data for the index BET show for both periods increased leverage coefficients with different indices as explanatory variable – for Period 2 – DJIA and Period 3 – DAX. The relative rate of change of leverage coefficients is very similar in both periods studied, which comes to direct that on the information asymmetry of BET is paramount pursuit of its own market impulses due to the established market trend, sensitivity to which is determine by the dynamics of the DJIA and DAX, but this dependency is not strong enough to be leading for BET. It should be noted that this reaction of the information asymmetry of the Romanian index is the same as direction and close in size to the external influence whether a crisis or post-crisis market.
  - The index SOFIX shows reduction of leverage coefficients for periods 2 and 3 while preserving the DJIA as an explanatory variable, both in crisis and in the post-crisis period. The leverage coefficients reduction is stronger in the Post-crisis Period 3 rather than during the Crisis Period 2, which showed a strong informational efficiency of the Bulgarian index tends to follow the established negative market trend. This significant reduction in the leverage coefficients for Post-crisis Period 3 result of taking into account of DJIA for returns and volatility of SOFIX can be explained by the fact that while in the Crisis Period 2 information asymmetry of SOFIX strongly follows the negative market impulses from their own market trend and from DJIA, then in a post-crisis market dominated largely by positive market impulses Bulgarian index severely limits its sensitivity to them. This reaction is completely opposite to the demonstrated toward negative market impulses during Crisis Period 2. In confirmation we can cite the values of the leverage coefficients for Crisis Period 2 (-0.10257 and -0.082071 – respectively with and without

accounting for DJIA) and two-times lower values in Period 3 (-0.040722 and -0.0043931 – respectively with and without considering the DJIA). So we can conclude that in case of negative market impulses, determined by an external factor - DJIA, Bulgarian index SOFIX shows their increased incorporation in his volatility, but demonstrates opposite information asymmetry response in terms of positive market impulses, determined by an external factor, expressed in their very limited coverage.

5. Empirical conclusions and generalizations

5.1. In terms of correlation values

- During **Pre-crisis Period** the Hungarian, the Czech and the Russian indices form and follow the long-term market trends in line with the positive news from the developed capital markets and in particular from the German index DAX. An exception to this reaction of CEE indices are the Romanian and the Bulgarian indices. The Romanian index demonstrates a relatively low correlation to the DJIA and DAX, and the SOFIX shows absents of significant correlation to U.S. or German index.
- Identically to Pre-crisis Period during the **Crisis Period** almost all CEE indices had shown significantly greater correlation with the dynamics of DAX rather than with DJIA. The strongest correlation is between DAX and the Czech index (0.6460), while the weaker is the one with the Romanian (0.1908). The exception is the Bulgarian index showing its highest correlation with the DJIA (0.3851).
- In a **post-crisis** recovery studied CEE indices showed still greater correlation of their dynamics with that of developed markets from which began the transfer of negative crisis influences during the global financial crisis of 2008. The highest degree of correlation is that between DAX and Russian index (0.7027). The lowest is for DAX and the Romanian (0.4509). From all surveyed CEE indices only the Bulgarian index shows its higher correlation to the U.S. index in continuation of the trend established during the Crisis Period.

5.2. Informational efficiency of the studied CEE indices

The Bulgarian and the Romanian indices showed disposition for faster and more sensitive reaction to negative market impulses, typical for the ***Crisis Period***, in contrast to a moderate incorporation of the positive market impulses specific to the Pre-crisis Period. Incorporation of the market information by SOFIX during Crisis Period is so accelerated that when it becomes publicly available at the time t much of the content is already included in the values of SOFIX under the form of strongly followed market trend. This type of reaction is opposite to the behavior from other CEE indices which follows more sustainable market trends during the pre-crisis period and gives much lower significance of the new market information. This market behavior changes during the Crisis Period, showing an enhanced response only to the short-term market fluctuations. During the Post-crisis Period the Bulgarian and the Romanian indices are showing predisposition to the short-term market trends. This is opposite to the other CEE indices which tend to form and pursue longer-term market trends.

5.3. Information asymmetry of the studied CEE indices

- The observed information asymmetry indicates that the Romanian, Hungarian, Russian and the Bulgarian indices during the Crisis Period showed significant increase of their volatility response to market impulses, in comparison with the Pre-crisis Period. This in the crisis condition leads to the greater increase of market volatility.
- The only exception is the reaction of the Czech index. This index strongly follows the market trends in conditions of growing market (Pre-crisis Period), leading to a strong positive reaction to the market information and a greater reduction in volatility. In times of crisis and negative market impulses the PXI shows a weaker response to market information and follow relatively long-term trends showing weaker increase in volatility.
- In the Post-crisis Period based on the observed levels of information asymmetry, we can group the indices studied in the following sequence. The first group consists of the Romanian, Russian and Bulgarian indices which are showing a post-crisis "cushioning" of the information asymmetry as they decrease the strength of their response to the market information and consequently reduction in the market volatility. With the exception of RTS established post-crisis levels of information asymmetry have the potential for significant increase of volatility in the presence of negative market impulses compared to Pre-crisis Period. The other group consists of the Hungarian and the Czech indices which are showing a faster recovery leading to a positive market impulse producing the highest decrease in the volatility of return on those markets. However, this result must be interpreted with caution because the emergence of negative market impulses would lead to the strongest increase in volatility of all studied indices.
- Summarizing for the informational asymmetry of all the studied indices we could point out that they show a weakening of the volatility of their returns. Nevertheless the markets remain with a high potential for relatively strong reaction in the emergence of the negative market impulses compared to the pre-crisis period.

5.4. Conclusions about volatility co-movement based on the impact of the DJIA and DAX on returns and volatility of CEE indices

1. There is a clear separation of the studied indices into two groups according to deterministic effects of DJIA and DAX. The first includes Hungarian, Czech and Russian indexes are clearly showing a leading role for their dynamics by the German index DAX, for all studied periods. The second group includes the Romanian index, showing a hesitating reaction to the deterministic influence of DJIA and DAX, and the

Bulgarian index – where when there is a significant external influence it is always by the DJIA (Crisis Period and Post-crisis Period).

2. The inclusion in the model of return on Hungarian, Czech and Russian indices of DAX, as a variable, leads to adjustment in their information efficiency attributable to the impact of the German index. Increased information efficiency of the Russian and the Czech indices showed that in the post-crisis market dynamics of the two indices is determined by the dynamics of DAX and generally followed a stronger post-crisis market trend. The information efficiency of the Hungarian index marked a strong predisposition to follow short-term market trends. Such behaviour in the post-crisis period can be determined as existence of a recovering market with high risk potential in which market recovery processes do not form a long-term trend, and give greater weight to short-term market fluctuations.
3. In times of crisis the Bulgarian and the Romanian indices showed a tendency to form and follow long-term market trends. The inclusion of the U.S. index in the model of returns of those indexes leads to reinforcing this tendency explained by the direct reflection of the dynamics of the DJIA.
4. During the Post-crisis Period the dynamics of the Romanian index is determined by the DAX and the index as a whole is more likely to follow the established post-crisis market trend, rather than short-term market fluctuations. It should be noted that the stability of the post-crisis recovery market trend is lower compared to the one with which BET followed the negative market dynamics during the Crisis Period. The inclusion of the DJIA in the model of return of the Bulgarian index during the Post-crisis Period leads to relatively very low change of its information efficiency. This combined with a reduction of the influence of the relatively long-term market trends gives greater weight to short-term market fluctuations for the index volatility.
5. In the pre-crisis and crisis periods the response of Czech index to the market impulses is determined in the highest degree from the dynamics of DAX compared to other studied CEE indices. During the Post-crisis Period the Hungarian index is leading in this aspect. The Hungarian index shows a stronger pursuit of short-term market fluctuations in the conditions of a recovering post-crisis market. As far as market information is positive BUX will achieve greater reduction of the volatility, hence a faster recovery. The situation still remains in a high risk potential, because of the emergence of the negative market impulses, and especially from DAX, which will increase the volatility and instability of the Hungarian capital market.
6. The Russian index in its post-crisis recovery strongly follows the positive market impulses and form very strong market trend which reflects in a significant degree the market dynamics of DAX. Thus, the available positive market impulses lead to significant reduction in the volatility of the Russian index. But like the Hungarian index, this situation is related to increased risk exposure since a shift of positive to negative market impulses well lead to significant increase in volatility of the market.
7. In general the Romanian index demonstrates a stronger pursuit of its own market impulses in consistency with the established market trend, sensitivity to which is

determined by the dynamics of the indexes DJIA and DAX, but this dependency is not strong enough to be leading for BET. It should be noted that this reaction of the information asymmetry of the Romanian index is the same in direction and close in size to the external influence whether in crisis or post-crisis market.

8. While in the Crisis Period the information asymmetry of the Bulgarian index is determined by the strong sensitivity to negative market impulses from its own market trend, as well as from DJIA, in a post-crisis market dominated largely by positive market impulses, SOFIX severely limits its sensitivity to them. Such a reaction is completely opposite to the one demonstrated toward negative market impulses during Crisis Period.

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Table 1

Correlation between the indices BET, RTS, WIG, BUX, PXI, SOFIX, DJIA and DAX for Pre-crisis Period 1

Period 1	BET_t	BUX_t	PXI_t	RTS_t	$SOFIX_t$	$SOFIX_t$	RTS_t	PXI_t	BUX_t	BET_t	
$DJIA_t$	0.0193	0.1632	0.1758	-0.0213	-0.0026	-0.0323	0.4327	0.4402	0.3860	0.0450	DAX_t
$DJIA_{t-1}$	0.0388	0.3427	0.3364	0.0475	0.0028	0.0184	0.0475	0.1149	0.1499	0.0613	DAX_{t-1}
$DJIA_{t-2}$	0.0240	0.0731	0.0034	0.0641	0.0197	-0.0175	0.0641	-0.0105	0.0642	-0.0128	DAX_{t-2}
$DJIA_{t-3}$	0.0433	0.0299	0.0326	-0.0072	-0.0307	0.0331	-0.0072	0.0154	0.0320	0.0037	DAX_{t-3}
$DJIA_{t-4}$	0.1109	0.0613	-0.0051	-0.0401	0.0545	0.0351	-0.0401	-0.0132	0.0545	0.0380	DAX_{t-4}
$DJIA_{t-5}$	0.0324	-0.0130	-0.0078	0.0956	0.0670	0.0677	0.0956	0.0438	0.0245	0.0231	DAX_{t-5}
$DJIA_{t-6}$	0.0180	-0.0374	-0.0318	0.0317	0.0240	0.0188	0.0317	0.0142	0.0453	0.0051	DAX_{t-6}
$DJIA_{t-7}$	-0.0752	-0.0235	-0.0071	-0.0192	0.0505	0.0572	-0.0192	-0.0591	-0.0439	-0.0055	DAX_{t-7}
$DJIA_{t-8}$	0.0097	-0.0265	-0.0460	-0.0536	0.0524	0.0048	-0.0536	-0.0528	-0.0118	0.0418	DAX_{t-8}
$DJIA_{t-9}$	-0.0184	-0.0057	-0.0734	0.0473	0.0327	0.0156	0.0473	-0.0366	0.0090	-0.0208	DAX_{t-9}
$DJIA_{t-10}$	-0.0121	0.0242	0.0425	-0.0423	0.0316	0.0359	-0.0423	0.0044	0.0331	0.0126	DAX_{t-10}

Table 2

Correlation between the indices BET, RTS, WIG, BUX, PXI, SOFIX, DJIA and DAX for Crisis Period 2

Period 2	BET_t	BUX_t	PXI_t	RTS_t	$SOFIX_t$	$SOFIX_t$	RTS_t	PXI_t	BUX_t	BET_t	
$DJIA_t$	0.0838	0.4142	0.4009	0.0186	0.0679	0.2642	0.5537	0.6460	0.6372	0.1246	DAX_t
$DJIA_{t-1}$	0.1416	0.3039	0.3848	0.0523	0.3851	0.2802	0.1693	0.2050	0.1412	0.1908	DAX_{t-1}
$DJIA_{t-2}$	-0.0475	-0.0390	-0.0631	0.0046	-0.0021	0.0167	0.0303	-0.0096	-0.1101	-0.0097	DAX_{t-2}
$DJIA_{t-3}$	0.0278	-0.1081	0.0110	0.0132	-0.0253	-0.0344	0.0050	-0.0711	-0.0247	-0.0223	DAX_{t-3}
$DJIA_{t-4}$	-0.0058	0.1296	-0.0395	-0.0168	0.0186	0.0852	0.0487	0.0474	0.0848	-0.0145	DAX_{t-4}
$DJIA_{t-5}$	0.0266	0.0406	0.0363	-0.0014	0.0708	0.0879	0.0223	0.0244	0.0515	0.0024	DAX_{t-5}
$DJIA_{t-6}$	0.0166	0.0265	0.0201	9.5274 e-004	0.0283	0.0082	-0.0218	-0.0237	0.0475	0.0664	DAX_{t-6}
$DJIA_{t-7}$	0.0232	-0.0309	-0.0142	0.0081	0.0277	0.0635	0.0241	0.0338	-0.0409	0.0211	DAX_{t-7}
$DJIA_{t-8}$	-0.0097	0.0300	0.0417	-0.0116	0.0294	0.0124	-0.0270	0.0187	0.0152	0.0033	DAX_{t-8}
$DJIA_{t-9}$	-0.0024	0.0921	0.0578	0.0055	0.0403	-0.0323	-0.0527	-0.0222	0.0793	0.0211	DAX_{t-9}
$DJIA_{t-10}$	0.0479	0.1188	-0.0080	0.0125	0.0284	0.0267	-0.0322	-0.0018	0.0337	-0.0373	DAX_{t-10}

Table 3

Correlation between the indices BET, RTS, WIG, BUX, PXI, SOFIX, DJIA and DAX for Post-crisis Period 3

Period 3	BET_t	BUX_t	PXI_t	RTS_t	$SOFIX_t$	$SOFIX_t$	RTS_t	PXI_t	BUX_t	BET_t	
$DJIA_t$	0.3107	0.5274	0.4897	0.5726	0.0824	0.2044	0.7027	0.6367	0.6432	0.4509	DAX_t
$DJIA_{t-1}$	0.2787	0.0544	0.2544	0.2458	0.3224	0.2386	0.2055	0.2208	0.0035	0.2002	DAX_{t-1}
$DJIA_{t-2}$	0.0111	0.0260	0.0167	0.0846	0.0247	0.0312	0.0228	-0.0597	-0.0457	0.0277	DAX_{t-2}
$DJIA_{t-3}$	0.0434	-0.0556	-0.0640	-0.0472	0.0212	-0.0043	-0.0502	-0.1154	-0.0048	-0.0240	DAX_{t-3}
$DJIA_{t-4}$	-0.0971	0.0380	-0.0442	0.0136	-0.0628	-0.0224	-0.0016	0.0099	0.0118	-0.0469	DAX_{t-4}
$DJIA_{t-5}$	0.0622	-0.0566	-0.0643	-0.0926	0.0357	-0.0032	-0.0732	0.0013	0.0033	0.0549	DAX_{t-5}
$DJIA_{t-6}$	-0.0124	-0.0487	0.0383	-0.0176	0.0713	0.0548	-0.0840	0.0216	-0.0400	-0.0012	DAX_{t-6}
$DJIA_{t-7}$	0.0307	-0.0169	0.0121	-0.0791	0.0741	0.0217	-0.0295	0.0048	-0.0695	-0.0345	DAX_{t-7}
$DJIA_{t-8}$	-0.0474	0.0057	-0.0285	0.0475	0.0256	0.0458	-0.0575	-0.0844	-0.0074	-0.0112	DAX_{t-8}
$DJIA_{t-9}$	0.0367	-0.0217	-0.0414	0.0066	0.0369	0.0427	0.0396	-0.0086	-0.0188	-1.0203 e-005	DAX_{t-9}
$DJIA_{t-10}$	0.0313	0.0416	0.0654	0.0270	-0.0101	-0.0308	0.0298	0.0799	0.0371	0.0697	DAX_{t-10}

Table 4

The highest observed positive and negative correlation values between the studied indices

Periods	Positive values		Negative values	
	Lags	Correlation values	Lags	Correlation values
BET and DJIA				
2005-2006	$t-4$	0.1109	$t-7$	-0.0752
2007-2009	$t-1$	0.1416	$t-2$	-0.0475
2010-2011	t	0.3107	$t-4$	-0.0971
BET and DAX				
2005-2006	$t-1$	0.0613	$t-9$	-0.0208
2007-2009	$t-1$	0.1908	$t-10$	-0.0373
2010-2011	t	0.4509	$t-4$	-0.0469
BUX and DJIA				
2005-2006	$t-1$	0.3427	$t-6$	-0.0374
2007-2009	t	0.4142	$t-3$	-0.1081
2010-2011	t	0.5274	$t-5$	-0.0566
BUX and DAX				
2005-2006	t	0.3860	$t-7$	-0.0439
2007-2009	t	0.6372	$t-2$	-0.1101
2010-2011	t	0.6432	$t-7$	-0.0695
PXI and DJIA				
2005-2006	$t-1$	0.3364	$t-9$	-0.0734
2007-2009	t	0.4009	$t-2$	-0.0631
2010-2011	t	0.4897	$t-5$	-0.0643

PXI and DAX				
2005-2006	t	0.4402	$t-7$	-0.0591
2007-2009	t	0.6460	$t-3$	-0.0711
2010-2011	t	0.6367	$t-8$	-0.0844
RTS and DJIA				
2005-2006	$t-5$	0.0956	$t-10$	-0.0423
2007-2009	$t-1$	0.0523	$t-4$	-0.0168
2010-2011	t	0.5726	$t-5$	-0.0926
RTS and DAX				
2005-2006	t	0.4327	$t-10$	-0.0662
2007-2009	t	0.5537	$t-3$	-0.0711
2010-2011	t	0.7027	$t-5$	-0.0732
SOFIX and DJIA				
2005-2006	$t-5$	0.0670	$t-3$	-0.0307
2007-2009	$t-1$	0.3851	$t-3$	-0.0253
2010-2011	$t-1$	0.3224	$t-4$	-0.0628
SOFIX and DAX				
2005-2006	$t-5$	0.0677	t	-0.0323
2007-2009	$t-1$	0.2802	$t-3$	-0.0344
2010-2011	$t-1$	0.2386	$t-10$	-0.0308

Table 5

Test statistics from Engle ARCH test of the residuals ε_t from return model of the following indices:

A) For BET

BET	Lags	1	2	6	12	18	24
Period 1	ARCH - stat	25.2952	26.9539	29.1312	48.3551	50.4956	80.0124
	pV	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 2	ARCH - stat	65.4724	92.7429	95.1970	112.8256	116.6622	120.4331
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 3	ARCH - stat	36.3940	36.8086	70.7246	73.0246	75.4630	79.9201
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150

B) For BUX

BUX	Lags	1	2	6	12	18	24
Period 1	ARCH - stat	0.8642	3.7424	35.6597	41.4107	45.9994	51.2059
	pV	0.3526	0.1539	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 2	ARCH - stat	112.7581	123.3293	199.6401	233.2178	250.8217	261.7454
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 3	ARCH - stat	20.9882	21.0617	26.8781	35.3944	38.9129	45.7695
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150

C) For PXI

PXI	Lags	1	2	6	12	18	24
Period 1	ARCH - stat	4.4802	33.9450	49.7775	54.5368	75.1472	84.1905
	pV	0.0343	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 2	ARCH - stat	98.9560	158.7135	186.4196	222.9964	236.1600	240.2502
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 3	ARCH - stat	24.1282	28.9790	50.5384	71.0413	75.7012	83.4673
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150

D) For RTS

RTS	Lags	1	2	6	12	18	24
Period 1	ARCH - stat	18.8662	52.8919	59.9643	68.4060	106.9094	118.0484
	pV	1.4021e-005	3.2708e-012	4.5768e-011	6.3568e-010	1.1768e-014	2.1538e-014
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 2	ARCH - stat	25.6795	45.9116	94.3409	187.4127	235.5136	251.1107
	pV	4.0309e-007	1.0726e-010	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 3	ARCH - stat	26.1136	30.1237	42.5363	62.6749	63.9409	64.9208
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150

E) For SOFIX

SOFIX	Lags	1	2	6	12	18	24
Period 1	ARCH - stat	81.7450	81.9475	105.6209	109.6435	126.2178	143.9475
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 2	ARCH - stat	103.0300	168.1993	193.2265	201.7080	214.4056	228.4958
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150
Period 3	ARCH - stat	78.0423	103.3071	107.7796	109.8038	117.3538	120.4110
	pV	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	CV	3.8415	5.9915	12.5916	21.0261	28.8693	36.4150

Table 6

Test statistics from Akaike (AIC) information criteria test for for compared EGARCH models:

A) For BET

Akaike Information Criterion for estimated model				
Period 1	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-2.6278e+003	-2.6405e+003	-2.6333e+003	**-2.6407e+003**
	EGARCH (2,2) – normal distribution		EGARCH (2,2) - t - distribution	
AIC	-2.6407e+003		**-2.6676e+003**	
Period 2	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	**-3.4763e+003**	-3.4739e+003	-3.4763e+003	-3.4756e+003
	EGARCH (1,1) – normal distribution		EGARCH (1,1) - t - distribution	
AIC	-3.4763e+003		**-3.4991e+003**	
Period 3	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-2.9842e+003	**-2.9880e+003**	-2.9864e+003	-2.9863e+003
	EGARCH (1,2) – normal distribution		EGARCH (1,2) - t - distribution	
AIC	-2.9880e+003		**-3.0033e+003**	

B) For BUX

Akaike Information Criterion for estimated model				
Period 2	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-3.8984e+003	-3.8950e+003	-3.8967e+003	-3.8928e+003
	EGARCH (1,1) – normal distribution		EGARCH (1,1) - t - distribution	
AIC	-3.8984e+003		**-3.9024e+003**	
Period 3	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-2.7471e+003	-2.7470e+003	**-2.7474e+003**	-2.7467e+003
	EGARCH (2,1) – normal distribution		EGARCH (2,1) - t - distribution	
AIC	-2.7474e+003		**-2.7660e+003**	

C) For PXI

Akaike Information Criterion for estimated model				
Period 1	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	482.2441	420.7374	-834.2355	**-3.1746e+003**
	EGARCH (2,2) – normal distribution		EGARCH (2,2) - t - distribution	
AIC	-3.1746e+003		**-3.2104e+003**	
Period 2	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-4.0495e+003	**-4.0543e+003**	-4.0517e+003	-4.0542e+003
	EGARCH (1,2) – normal distribution		EGARCH (1,2) - t - distribution	
AIC	-4.0543e+003		**-4.0687e+003**	
Period 3	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-3.0272e+003	**-3.0368e+003**	-3.0344e+003	-3.0358e+003
	EGARCH (1,2) – normal distribution		EGARCH (1,2) - t - distribution	
AIC	-3.0368e+003		**-3.0366e+003***	

***** Although formally a lower AIC test statistics is for model with normal distribution we adopt the model with Student t - distribution. Relatively very close values of AIC test statistics for compared models and as a result of a subsequent measurement of AIC test statistics for EGRACH model with data from PXI and from DJIA and DAX indices, conclusively establish the superiority of EGRACH models using t-distribution and their results will be used as representative data from the index PXI.

D) For RTS

Akaike Information Criterion for estimated model				
Period 1	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-2.7497e+003	**-2.7529e+003**	-2.7485e+003	-2.7509e+003
	EGARCH (1,2) – normal distribution		EGARCH (1,2) - t - distribution	
AIC	-2.7529e+003		**-2.7878e+003**	
Period 2	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-3.5294e+003	-3.5293e+003	-3.5261e+003	-3.5256e+003
	EGARCH (1,1) – normal distribution		EGARCH (1,1) - t - distribution	
AIC	-3.5294e+003		**-3.5489e+003**	
Period 3	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-2.6627e+003	-2.6658e+003	-2.6644e+003	**-2.6682e+003**
	EGARCH (2,2) – normal distribution		EGARCH (2,2) - t - distribution	
AIC	-2.6682e+003		**-2.6719e+003**	

E) For SOFIX

Akaike Information Criterion for estimated model				
Period 1	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-3.4508e+003	-3.4611e+003	-3.4539e+003	**-3.4615e+003**
	EGARCH (2,2) – normal distribution		EGARCH (2,2) - t - distribution	
AIC	-3.4615e+003		**-3.4835e+003**	

Period 2	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	-4.1111e+003	-4.1086e+003	-4.1096e+003	**-4.1129e+003**
	EGARCH (2,2) – normal distribution		EGARCH (2,2) - t - distribution	
AIC	-4.1129e+003		**-4.1315e+003**	
Period 3	EGARCH (1,1)	EGARCH (1,2)	EGARCH (2,1)	EGARCH (2,2)
AIC	**-3.3401e+003**	-3.3376e+003	-3.3381e+003	-3.3361e+003
	EGARCH (1,1) – normal distribution		EGARCH (1,1) - t - distribution	
AIC	-3.3401e+003		**-3.3542e+003**	

Table 7

Results of the EGARCH model with t – distribution and data from the BET index

A) For DJIA

BET	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (1,1) - t		EGARCH (1,2) - t	
	Without $DJIA$	With $DJIA_{t-4}$	Without $DJIA$	With $DJIA_{t-1}$	Without $DJIA$	With $DJIA_t$
C (T Statistic)	0.00038122 (0.6555)	0.000289 (0.4912)	-0.00023197 (-0.3487)	-0.00047621 (-0.7434)	-0.00021166 (-0.4444)	-0.00037113 (-0.7965)
ϕ_1	0.082099 (1.5993)	0.081725 (1.6009)	0.11681 (2.8441)	0.075054 (1.9644)	-0.036278 (-0.7239)	-0.023254 (-0.5002)
ϕ_2	-	0.12888 (1.3510)	-	0.27366 (7.0868)	-	0.24983 (5.6063)
α_0	-0.080626 (-0.7269)	-0.091069 (-0.7344)	-0.94778 (-3.6443)	-1.3918 (-3.8922)	-0.30939 (-2.0958)	-0.37376 (-2.0839)
β_1	1.5291 (7.0400)	1.5042 (6.4206)	0.87823 (26.3463)	0.82029 (17.6956)	0.96468 (56.8606)	0.95751 (46.7221)
β_2	-0.5386 (-2.5893)	-0.51491 (-2.3007)	-	-	-	-
α_1	0.53658 (4.2475)	0.53019 (4.1641)	0.50169 (6.7136)	0.51811 (5.6633)	0.46993 (4.2707)	0.4451 (4.0026)
α_2	-0.48348 (-3.8393)	-0.47202 (-3.6570)	-	-	-0.25505 (-2.3424)	-0.21732 (-1.9848)
γ_1	-0.05969 (-0.7836)	-0.055302 (-0.7055)	-0.093246 (-1.9714)	-0.12963 (-2.3713)	-0.10199 (-1.2939)	-0.077345 (-0.9499)
γ_2	0.05473 (0.7061)	0.048235 (0.6021)	-	-	0.022768 (0.2858)	-0.0059979 (-0.0744)
Persistence	**0.9905**	**0.98929**	**0.87823**	**0.82029**	**0.96468**	**0.95751**
AIC	**-2.6676e+003**	**-2.6674e+003**	**-3.4991e+003**	**-3.5164e+003**	**-3.0033e+003**	**-3.0292e+003**

B) For DAX

BET	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (1,1) - t		EGARCH (1,2) - t	
	Without DAX	With DAX_{t-1}	Without DAX	With DAX_{t-1}	Without DAX	With DAX_t
C (T Statistic)	0.00038122 (0.6555)	0.0003339 (0.5740)	-0.00023197 (-0.3487)	-0.00029529 (-0.4436)	-0.00021166 (-0.4444)	-0.00059195 (-1.3800)
ϕ_1	0.082099 (1.5993)	0.080045 (1.5524)	0.11681 (2.8441)	0.093637 (2.2939)	-0.036278 (-0.7239)	-0.026601 (-0.6342)
ϕ_2	-	0.029419 (0.6723)		0.063349 (4.3528)	-	0.33199 (11.0633)
α_0	-0.080626 (-0.7269)	-0.079979 (-0.7266)	-0.94778 (-3.6443)	-0.86513 (-3.4379)	-0.30939 (-2.0958)	-0.63915 (-2.1442)
β_1	1.5291 (7.0400)	1.5279 (7.0971)	0.87823 (26.3463)	0.88904 (27.6435)	0.96468 (56.8606)	0.92768 (27.3808)

β_2	-0.5386 (-2.5893)	-0.53731 (-2.6053)	-	-	-	-
α_1	0.53658 (4.2475)	0.54156 (4.3019)	0.50169 (6.7136)	0.4645 (6.3033)	0.46993 (4.2707)	0.48777 (4.1555)
α_2	-0.48348 (-3.8393)	-0.48845 (-3.8784)	-	-	-0.25505 (-2.3424)	-0.19608 (-1.6448)
γ_1	-0.05969 (-0.7836)	-0.059971 (-0.7871)	-0.093246 (-1.9714)	-0.075195 (-1.6645)	-0.10199 (-1.2939)	-0.078243 (-0.9035)
γ_2	0.05473 (0.7061)	0.055127 (0.7115)	-	-	0.022768 (0.2858)	-0.029016 (-0.3371)
Persistence	**0.9905**	**0.99059**	**0.87823**	**0.88904**	**0.96468**	**0.92768**
AIC	**-2.6676e+003**	**-2.6670e+003**	**-3.4991e+003**	**-3.5057e+003**	**-3.0033e+003**	**-3.0888e+003**

Table 8

Results of the EGARCH model with t – distribution and data from the BUX index

A) For DJIA

BUX	Period 2		Period 3	
	EGARCH (1,1) - t		EGARCH (2,1) - t	
	Without $DJIA$	With $DJIA_t$	Without $DJIA$	With $DJIA_t$
C (T Statistic)	-0.00033967 (-0.6187)	-0.00017022 (-0.3363)	-0.00034355 (-0.5488)	-0.0005279 (-0.8580)
ϕ_1	0.046464 (1.2705)	0.064525 (1.9184)	-0.051979 (-1.0999)	-0.053228 (-1.1487)
ϕ_2	-	0.44649 (11.2252)		0.19189 (3.4901)
α_0	-0.1413 (-2.1443)	-0.15957 (-1.9113)	-0.41025 (-1.8919)	-0.29064 (-1.6411)
β_1	0.98247 (120.4773)	0.98061 (96.8663)	0.41813 (1.3485)	0.43426 (1.2820)
β_2	-	-	0.53244 (1.7476)	0.53075 (1.5844)
α_1	0.24 (5.7047)	0.24761 (5.4065)	0.23204 (2.8727)	0.21951 (2.7654)
α_2	-	-	-	-
γ_1	-0.06608 (-2.8396)	-0.057175 (-2.0873)	-0.13004 (-2.6100)	-0.12059 (-2.5432)
γ_2	-	-	-	-
Persistence	**0.98247**	**0.98061**	**0.95057**	**0.96501**
AIC	**-3.9024e+003**	**-4.0041e+003**	**-2.7660e+003**	**-2.7721e+003**

B) For DAX

BUX	Period 2		Period 3	
	EGARCH (1,1) - t		EGARCH (2,1) - t	
	Without DAX	With DAX_t	Without DAX	With DAX_t
C (T Statistic)	-0.00033967 (-0.6187)	-0.00043729 (-1.0210)	-0.00034355 (-0.5488)	-0.00057823 (-1.1137)
ϕ_1	0.046464 (1.2705)	0.074245 (2.7214)	-0.051979 (-1.0999)	-0.079383 (-2.4501)
ϕ_2	-	0.69289 (23.2924)		0.6514 (18.6354)

α_0	-0.1413 (-2.1443)	-0.20242 (-2.2076)	-0.41025 (-1.8919)	-0.24488 (-1.1463)
β_1	0.98247 (120.4773)	0.97606 (90.5022)	0.41813 (1.3485)	0.35344 (0.8172)
β_2			0.53244 (1.7476)	0.61837 (1.4402)
α_1	0.24 (5.7047)	0.24812 (5.2813)	0.23204 (2.8727)	0.16543 (2.3175)
α_2	-	-	-	-
γ_1	-0.06608 (-2.8396)	-0.054938 (-1.8301)	-0.13004 (-2.6100)	-0.085955 (-2.0596)
γ_2	-	-	-	-
Persistence	**0.98247**	**0.97606**	**0.95057**	**0.97181**
AIC	**-3.9024e+003**	**-4.2573e+003**	**-2.7660e+003**	**-2.9815e+003**

Table 9

Results of the EGARCH model with t – distribution and data from the PXI index

A) For DJIA

PXI	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (1,2) - t		EGARCH (1,2)	
	Without $DJIA$	With $DJIA_{t-1}$	Without $DJIA$	With $DJIA_t$	Without $DJIA$	With $DJIA_t$
C (T Statistic)	0.0014053 (3.6544)	0.0012061 (3.2584)	-1.6793e-006 (-0.0035)	-9.0172e-005 (-0.1961)	-0.0002416 (-0.5004)	-0.00045018 (-1.0790)
ϕ_1	0.034103 (0.7225)	0.012701 (0.2985)	0.037963 (1.0635)	0.073134 (2.1228)	-0.0090299 (-0.1855)	0.0069122 (0.1725)
ϕ_2	-	0.41404 (7.075)	-	0.36691 (10.3287)	-	0.46228 (12.0035)
α_0	-1.2463 (-2.2743)	-0.36315 (-1.4739)	-0.24943 (-2.2751)	-0.40475 (-2.9432)	-0.24018 (-1.8990)	-0.30817 (-1.9891)
β_1	-0.016255 (-0.2692)	1.5986 (6.9542)	0.97016 (72.6499)	0.95196 (57.6697)	0.9734 (67.9977)	0.96653 (56.5096)
β_2	0.88253 (14.9548)	-0.63749 (-3.0568)	-	-	-	-
α_1	0.34422 (3.7478)	0.15545 (1.3243)	0.14981 (1.7559)	0.19127 (1.9659)	0.29861 (2.2505)	0.25788 (2.0999)
α_2	0.2011 (1.9331)	-0.018295 (-0.1083)	0.1943 (2.2882)	0.18562 (1.8924)	-0.086186 (-0.6627)	-0.01655 (-0.1307)
γ_1	-0.1007 (-1.6856)	-0.21521 (-2.7616)	-0.16473 (-2.8153)	-0.13291 (-2.0408)	-0.3093 (-4.1610)	-0.21229 (-2.5329)
γ_2	-0.11098 (-1.8889)	0.19691 (2.7511)	0.095586 (1.5573)	0.049276 (0.7437)	0.23053 (2.8809)	0.1518 (1.7291)
Persistence	**0,866275**	**0,96111**	**0.97016**	**0.95196**	**0.9734**	**0.96653**
AIC	**-3.2104e+003**	**-3.2558e+003**	**-4.0687e+003**	**-4.1456e+003**	**-3.0366e+003**	**-3.1396e+003**

B) For DAX

PXI	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (1,2) - t		EGARCH (1,2)	
	Without DAX	With DAX_t	Without DAX	With DAX_t	Without DAX	With DAX_t
C (T Statistic)	0.0014053 (3.6544)	0.00078484 (2.0663)	-1.6793e-006 (-0.0035)	-0.00020762 (-0.5216)	-0.0002416 (-0.5004)	-0.00026423 (-0.6439)
ϕ_1	0.034103 (0.7225)	0.056902 (1.3661)	0.037963 (1.0635)	0.052988 (1.8700)	-0.0090299 (-0.1855)	0.022427 (0.6091)
ϕ_2	-	0.35082 (8.2485)	-	-0.19938 (-2.0787)	-	0.48671 (17.3648)
α_0	-1.2463 (-2.2743)	-0.72658 (-1.2425)	-0.24943 (-2.2751)	-0.19938 (-2.0787)	-0.24018 (-1.8990)	-0.67759 (-1.9182)
β_1	-0.016255 (-0.2692)	1.2087 (1.9287)	0.97016 (72.6499)	0.97718 (88.0184)	0.9734 (67.9977)	0.92697 (24.1677)
β_2	0.88253 (14.9548)	-0.28613 (-0.4991)	-	-	-	-
α_1	0.34422 (3.7478)	0.12346 (0.8015)	0.14981 (1.7559)	0.28391 (2.7755)	0.29861 (2.2505)	0.29452 (2.4758)
α_2	0.2011 (1.9331)	0.12454 (0.4492)	0.1943 (2.2882)	-0.02066 (-0.2145)	-0.086186 (-0.6627)	-0.049042 (-0.4001)
γ_1	-0.1007 (-1.6856)	-0.13905 (-1.5756)	-0.16473 (-2.8153)	-0.084636 (-1.3420)	-0.3093 (-4.1610)	-0.075643 (-0.9720)
γ_2	-0.11098 (-1.8889)	0.073248 (0.7953)	0.095586 (1.5573)	0.052766 (0.8401)	0.23053 (2.8809)	0.0095121 (0.1204)
Persistence	**0,866275**	**0,92257**	**0.97016**	**0.97718**	**0.9734**	**0.92697**
AIC	**-3.2104e+003**	**-3.2578e+003**	**-4.0687e+003**	**-4.3715e+003**	**-3.0366e+003**	**-3.2137e+003**

Table 10

Results of the EGARCH model with t – distribution and data from the RTS index

A) For DJIA

RTS	Period 1		Period 2		Period 3	
	EGARCH (1,2) - t		EGARCH (1,1) - t		EGARCH (2,2) - t	
	Without $DJIA$	With $DJIA_{t-5}$	Without $DJIA$	With $DJIA_{t-1}$	Without $DJIA$	With $DJIA_t$
C (T Statistic)	0.0028733 (4.9002)	0.0029118 (4.8811)	0.00046044 (0.6934)	0.00045717 (0.6884)	0.00050485 (0.7360)	5.4663e-005 (0.0951)
ϕ_1	0.071416 (1.6454)	0.069623 (1.5958)	0.081024 (2.1098)	0.081867 (2.1166)	0.1251 (2.7582)	0.1051 (2.7277)
ϕ_2	-	-0.031567 (-0.4798)	-	0.0044698 (0.5518)	-	0.83495 (16.6701)
α_0	-0.5901 (-2.2841)	-0.58945 (-2.2927)	-0.078009 (-1.8163)	-0.077879 (-1.8169)	-0.15841 (-1.5206)	-0.099126 (-0.7804)
β_1	0.92944 (30.1955)	0.92951 (30.3505)	0.99 (176.5246)	0.99002 (176.9204)	1.3394 (6.0147)	1.5608 (5.8401)
β_2	-	-	-	-	-0.35842 (-1.6802)	-0.57229 (-2.2412)
α_1	0.20955 (1.6852)	0.21526 (1.7260)	0.16736 (4.2070)	0.16724 (4.2029)	-0.093155 (-0.7578)	0.1145 (1.1037)
α_2	0.11676 (0.9191)	0.11575 (0.9094)	-	-	0.1714 (1.3373)	-0.079099 (-0.7138)
γ_1	-0.14209 (-1.5971)	-0.14017 (-1.5698)	-0.074087 (-3.5749)	-0.074078 (-3.5733)	-0.3428 (-4.5630)	-0.24453 (-2.7689)

γ_2	0.083517 (0.9063)	0.08065 (0.8742)			0.28724 (3.9740)	0.22128 (2.7699)
Persistence	**0.92944**	**0.92951**	**0.99**	**0.99002**	**0.98098**	**0.98851**
AIC	**-2.7878e+003**	**-2.7860e+003**	**-3.5489e+003**	**-3.5479e+003**	**-2.6719e+003**	**-2.8438e+003**

B) For DAX

RTS	Period 1		Period 2		Period 3	
	EGARCH (1,2) - t		EGARCH (1,1) - t		EGARCH (2,2) - t	
	Without DAX	With DAX_t	Without DAX	With DAX_t	Without DAX	With DAX_t
C (T Statistic)	0.0028733 (4.9002)	0.002132 (3.5820)	0.00046044 (0.6934)	0.00051458 (0.9473)	0.00050485 (0.7360)	0.00017746 (0.3515)
ϕ_1	0.071416 (1.6454)	0.098498 (2.4912)	0.081024 (2.1098)	0.07815 (2.5153)	0.1251 (2.7582)	0.057507 (1.8618)
ϕ_2	-	0.52213 (8.1145)	-	0.80771 (21.1293)	-	0.80829 (24.8336)
α_0	-0.5901 (-2.2841)	-0.50324 (-1.9768)	-0.078009 (-1.8163)	-0.065696 (-1.7162)	-0.15841 (-1.5206)	-2.958 (-1.5790)
β_1	0.92944 (30.1955)	0.94118 (31.5215)	0.99 (176.5246)	0.992 (208.8053)	1.3394 (6.0147)	0.32089 (0.3462)
β_2	-	-	-	-	-0.35842 (-1.6802)	0.34259 (0.4480)
α_1	0.20955 (1.6852)	0.1498 (1.1076)	0.16736 (4.2070)	0.14557 (3.7246)	-0.093155 (-0.7578)	0.22843 (2.2223)
α_2	0.11676 (0.9191)	0.12057 (-2.0438)	-	-	0.1714 (1.3373)	0.18784 (0.7672)
γ_1	-0.14209 (-1.5971)	-0.18452 (-2.0438)	-0.074087 (-3.5749)	-0.061516 (-3.1950)	-0.3428 (-4.5630)	-0.14628 (-2.0318)
γ_2	0.083517 (0.9063)	0.15098 (1.6628)	-	-	0.28724 (3.9740)	-0.11436 (-0.7192)
Persistence	**0.92944**	**0.94118**	**0.99**	**0.992**	**0.98098**	**0.66348**
AIC	**-2.7878e+003**	**-2.8372e+003**	**-3.5489e+003**	**-3.8200e+003**	**-2.6719e+003**	**-2.9563e+003**

Table 11

Results of the EGARCH model with t – distribution and data from the SOFIX index

A) For DJIA

SOFIX	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (2,2) - t		EGARCH (1,1) - t	
	Without $DJIA$	With $DJIA_{t-5}$	Without $DJIA$	With $DJIA_{t-1}$	Without $DJIA$	With $DJIA_{t-1}$
C (T Statistic)	0.00062517 (2.6306)	0.00061926 (2.5960)	-0.00033985 (-0.7827)	-0.00063481 (-1.5013)	-0.00030641 (-0.9456)	-0.00056063 (-1.9148)
ϕ_1	0.19301 (3.8791)	0.18952 (3.8106)	0.16228 (4.1561)	0.13948 (3.9444)	0.096089 (1.9256)	0.048907 (1.0813)
ϕ_2	-	0.023822 (0.7348)	-	0.28447 (9.4265)	-	0.21828 (8.7975)
α_0	-0.021547 (-0.8185)	-0.021441 (-0.8175)	-1.2909 (-3.4980)	-1.4858 (-3.6744)	-1.3772 (-3.0673)	-1.4157 (-2.8831)
β_1	1.6409 (11.2704)	1.6402 (11.2922)	0.11397 (0.6643)	0.17965 (0.9949)	0.85591 (18.1925)	0.85311 (16.7092)
β_2	-0.64304 (-4.4699)	-0.64229 (-4.4750)	0.73285 (4.4792)	0.64572 (3.7398)	-	-
α_1	0.61041 (4.9262)	0.60895 (4.8602)	0.40767 (4.5194)	0.39884 (4.0265)	0.56972 (5.4487)	0.53769 (4.9808)

α_2	-0.5705 (-4.8590)	-0.56937 (-4.8027)	0.52244 (5.3272)	0.54585 (5.1058)	-	-
γ_1	0.043123 (0.5490)	0.042726 (0.5396)	-0.024383 (-0.4735)	-0.016999 (-0.2966)	-0.040722 (-0.7259)	-0.0043931 (-0.0779)
γ_2	-0.036328 (-0.4590)	-0.035918 (-0.4498)	-0.078187 (-1.4423)	-0.065072 (-1.0986)	-	-
Persistence	**0,99786**	**0,99791**	**0,84682**	**0,82537**	**0.85591**	**0.85311**
AIC	**-3.4855e+003**	**-3.4840e+003**	**-4.1315e+003**	**-4.2032e+003**	**-3.3542e+003**	**-3.4031e+003**

B) For DAX

SOFIX	Period 1		Period 2		Period 3	
	EGARCH (2,2) - t		EGARCH (2,2) - t		EGARCH (1,1) - t	
	Without DAX	With DAX_{t-5}	Without DAX	With DAX_{t-1}	Without DAX	With DAX_{t-1}
C (T Statistic)	0.00062517 (2.6306)	0.00063712 (2.6808)	-0.00033985 (-0.7827)	-0.00056799 (-1.3258)	-0.00030641 (-0.9456)	-0.0004471 (-1.4712)
ϕ_1	0.19301 (3.8791)	0.19335 (3.8767)	0.16228 (4.1561)	0.12465 (3.3424)	0.096089 (1.9256)	0.041099 (0.8391)
ϕ_2	-	-0.0097335 (-0.4204)	-	0.16891 (6.0125)	-	0.11283 (5.6475)
α_0	-0.021547 (-0.8185)	-0.022011 (-0.8180)	-1.2909 (-3.4980)	-1.3559 (-3.4344)	-1.3772 (-3.0673)	-1.2786 (-2.9817)
β_1	1.6409 (11.2704)	1.6399 (11.2612)	0.11397 (0.6643)	0.16286 (0.9189)	0.85591 (18.1925)	0.8672 (19.3394)
β_2	-0.64304 (-4.4699)	-0.64202 (-4.4629)	0.73285 (4.4792)	0.67706 (4.0600)	-	-
α_1	0.61041 (4.9262)	0.6129 (4.9594)	0.40767 (4.5194)	0.38763 (4.1354)	0.56972 (5.4487)	0.56258 (5.4098)
α_2	-0.5705 (-4.8590)	-0.57279 (-4.8960)	0.52244 (5.3272)	0.54324 (5.1941)	-	-
γ_1	0.043123 (0.5490)	0.04229 (0.5395)	-0.024383 (-0.4735)	-0.008121 (-0.1480)	-0.040722 (-0.7259)	-0.024631 (-0.4506)
γ_2	-0.036328 (-0.4590)	-0.035576 (-0.4504)	-0.078187 (-1.4423)	-0.08967 (-1.5633)	-	-
Persistence	**0,99789**	**0,99788**	**0,84682**	**0,83992**	**0.85591**	**0.8672**
AIC	**-3.4855e+003**	**-3.4837e+003**	**-4.1315e+003**	**-4.1640e+003**	**-3.3542e+003**	**-3.3776e+003**