# Behavior and Characteristics of the Balkan Stock Markets[!]

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The paper investigates the behavior and characteristics of Balkan Stock markets. We prove that Balkan stock markets have typical for the emerging markets high standard deviation, high kurtosis, high extreme values for the returns, mean value of the return different from the global market tendency and low level of correlations with the global markets. Although for the autocorrelation we obtain not synonymous results we accept them as not controversial to the main thesis. We apply Granger causality test in order to find the direction of information transmission. The results lead up to the conclusions that the more liberalized and integrated stock markets the more affected they are, and the more they affect other markets. We argue significant conditional heteroscedasticity in Greece, Turkey and Romania, in the residuals of the standard International Capital Asset Pricing Model. The results indicate that GARCH (1,1) – t model is more suitable for modeling all three Balkan stock markets among GARCH models. Our study describes Balkan markets as uncorrelated, uninfluenced each other and with unequal risk characteristics. Using existing portfolio opportunities by investors will develop more integration between local markets and will lead to establishing well developed integrated emerging markets on the Balkans.

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## 1. Introduction

Balkans can be clearly defined as a specific geographical, political and social part of Europe. Many economists have tried to describe the specifics of the economic system of this region and to define it as one of the specific economic region of Europe such as the Baltic countries or the Iberian countries.

The Balkan stock markets have passed through privatization and liberalization. Turkey undertook a process of stock market liberalization in early 1980s while Greece liberalized its stock market in the early 1990s. After the crash of communism Romania has started the process of privatization. Thanks to the liberalization and privatization the Balkan stock markets have registered sustainable growth in market capitalization.

This study is concentrated on Balkan stock markets. Our purpose is to find out if there are any common specifics of these markets. If such specifics exist we can prove that the Balkan markets should be accepted by the investors as one of the regional investment markets such as the Scandinavian stock market, the Iberian stock market or the Central European stock market.

The study is structured as follows. In part 2 we briefly describe the basic features of Emerging Equity Markets. In part 3 we present data and summary statistics of Balkan Stock Markets. Conclusions and directions for further research are in part 4.

## 2. Literature Review

There are numerous investigations on emerging equity markets accented to the different characteristics of emerging equity markets. Bekaert, Erb, Harvey, and Viskanta (1998) argue that emerging markets are highly non-normal. Moreover, seventeen of twenty stock markets exhibit positive skewness in the returns, and nineteen of twenty are leptokurtic over the investigated period April 1987-March 1997. Furthermore, there is no strong evidence that the non-normality found in many emerging market returns is becoming less prominent in the 1990s.

Erb, Harvey, Viskanta (1998) point out that correlation varies depending on both the state of economy and the state of the equity markets in each country. Correlation is higher in recessions and lower in recovers, than the average in both economic states. Moreover, the same asymmetry of correlation is observed in bear and bull markets: in bear markets, correlations are higher, in bull markets correlations are lower.

Harvey (1995) explains the high volatility of returns by (1) lack of diversification in the country index, (2) high risk exposures to volatile economic factors, and (3) time-variation in the risk exposures and/or incomplete integration into world capital market.

Harvey (1995b) finds that the serial correlation in emerging markets returns is much higher than observed in developed markets. He explains this feature as a lack of diversification and trading depth induces spurious serial correlation. There are emerging markets partially integrated into the world capital market. Factors that contribute to market integration are free access by foreigners to domestic capital markets and free access by domestic investors to international capital markets. Potential barriers to integration come in the form of: access, taxes, and information.

Harvey (1995a) documents small correlation among emerging markets. Surprisingly, he registers negative correlations (Argentina and Brazil, Pakistan and India). The correlation between emerging and developed markets is small average below 10 percent.

Shachmurove (1996) apply Vector Auto regression (VAR) models to trace the dynamic linkages across daily returns of Latin American stock indexes. The correlation coefficients are relatively low (below 10%), the highest coefficient is between Mexico and Brazil. He documents a negative correlation between Argentina and Brazil an interesting fact from portfolio management point of view. All stock indexes are first order integrated, I (1). He finds that the most influential market in the Latin America is the Argentinean one which Granger-cause the Brazilian stock market and the only affected market is the Brazilian one.

Shachmurove (2001) trace the dynamic co-movements among the stock indices for the seven emerging Middle East countries (Egypt, Israel, Jordan, Lebanon, Morocco, Oman, and Turkey). He documents low correlation and many are also negative an indication for ability for portfolio diversification. Shachmurove (2001) use three unit-root tests and finds that all stock indexes are first order integrated, I (1). He derives two important conclusions from documented relatively low inter-linkages among Middle East stock markets. The first is the presence of a further benefit from portfolio diversification. The second is that Middle East countries can benefit if they liberalize their stock markets.

Phylaktis and Ravazzolo (2001) examine stock market linkages of a group of Pacific-Basin emerging countries with US and Japan by estimating the multivariate cointegration model and the possibilities for portfolio diversification over the period 1980-1998. They find that investors have opportunities for portfolio diversification by investing in most of the Pacific-Basin stock markets.

Leong and Felmingham (2001) consider the interdependence of Japan's Nikkei, Taiwan Weighted, Singapore Strait Times, Korea Composite and Hang Seng indexes over the period July 8, 1990 – July 6, 2000. They argue the presence of market segmentation and market efficiency limiting the opportunities for portfolio diversification.

Leo and Kendal (1996) conduct market efficiency test of stock markets of Singapore, Malaysia and Indonesia. They find that the three markets are weak form efficient and are not semi-strong form efficient for the analyzed period 1975-1992. Several studies derive the basic characteristics of each Balkan stock market.

Chortareas et al. (2000) analyze time series properties of daily returns of the Athens Stock Exchange (ASE) composite index over the period 1987-1997. They reject the null hypothesis for normality for both daily and weekly returns of ASE index. The first and second order autocorrelations of both daily and weekly returns are significant. Using Nelson's (1991) EGARCH-M model with Student t distributed innovations they find significant price of risk and volatility asymmetry.

Alexakis and Xanthakis (1995) examine the day of the week effect in the Greek stock market over the period January 1985 - February. They conclude that for the whole period (1985-1994) the average returns on Tuesday are negative. The same phenomenon is observed for the sub-period 1985-1987. The highest average return of the week is observed on Friday for the same sub-period. For the sub-period 1988-1994 both Mondays and Tuesdays presented negative average returns, with the highest negative returns being on Mondays. Alexakis and Xanthakis (1995) document that the Mondays have the highest risk.

Lyroudi, Subeniotis, and Komisopoulos (2002) reexamine the day of the week effect in Athens Stock Exchange for the period 03/01/1994-30/12/1999. They document significant day of the week effect in the Greek Stock market during the period 25/07/1997-30/12/1999 in a different form than the one observed in the other developed capital markets since the negative returns occur on Thursdays instead of Mondays or Tuesdays.

Niarchos et al. (1999) investigate the international transmission of information between the US and Greek stock exchanges using daily returns of the ASE and S&P

500 indexes. They find that both markets are not related each other, either in the short run or in the long run.

Apergis and Eleptheriou (2001) investigate the volatility of the Athens Stock excess stock returns over the period 1990-1999 through the comparison of various ARCH-family models. They document significant evidence for asymmetry in stock returns, which is captured by a quadratic GARCH specification model, while there is strong persistence of shocks into volatility.

Kavussanos and Phylaktisa (2001) examine the effects of different trading systems on the relation between trading activity and conditional volatility, on the probability distribution of returns, and on the asymmetric impact of news. The paper draws on the experience of the Athens Stock Exchange and finds that the establishment of the automated trading system caused a) the asymmetric effects to disappear; b) the persistence of volatility to be reduced dramatically; and c) improved forecasting of trading activity leaving only news to affect volatility.

Balaban (1995a, 1995b) tests the informational efficiency of the Istanbul stock exchange for the period January 1988-Agust 1994. The results indicate that the Istanbul stock exchange (ISE) is neither weak form nor semi-strong efficient. Balaban (1995a) shows that there are no significant differences among daily returns in Istanbul stock exchange. In addition, he derives some characteristics of the market – high risk and positive and significant first-order autocorrelation. The basic descriptive characteristics of the ISE are derived in Balaban (1995b). He analyze the daily and weekly returns of ISE Composite index over the period January 1988-Agust 1994. In contrast with Balaban (1995a) he finds that Friday is the only day with positive average returns. The highest volatility if observed on Monday. Again he rejects the weak form efficiency for both daily and weekly data in ISE.

Balaban and Kunter (1996) reject the null hypothesis of semi-strong market efficiency in stock market, foreign market and interbank money market for the period January 1989 – July 1995. They find that these markets are pairwise independent.

Yalmaz (2001) investigates the relationship between market development and efficiency. Applying the variance-ratio based multiple comparison tests on weekly and daily returns for 21 emerging stock markets he finds that over the time there is a move toward market efficiency.

Codirlaşu (2000) tests the information efficiency of the Romanian capital market. He rejects all forms of market efficiency in Romanian capital market. In addition, he documents some characteristics of the Romanian stock market – first-order integration, non-normality, and non-linearity. Codirlaşu (2000) find significant January and day of the week effects.

Progonaru and Apostol (2000) review the evolution of the Romanian capital market. They draw up the gray areas of the development of the Romanian capital market – low minority shareholders protection, insufficient regulation of the RASDAQ market, poor custody regulation, poor disclosure requirements, specific accounting standards etc. Progonaru and Apostol (2000) document the low correlation between the evolution of the Romanian capital market and Central and Eastern European (CEE) capital markets. CEE capital markets are sensitive to foreign capital movements and they attract foreign investors by both market and non-market instruments – social and political stability, favorable macroeconomic environment, listing of high quality companies, requirements for strong corporate governance. The Progonaru and Apostol's study explains the reasons for the rejection of the null hypothesis of market efficiency by Codirlaşu (2000).

Drakos and Kutan (2001) extent the literature focused on individual characteristics of the Greek and Turkish stock markets examining the short-run and long-run financial linkages between Greek and Turkish financial markets. They find that both stock markets are short-run and long-run interdependent and argue contagion between both foreign exchange markets.

Motivated by Drakos and Kutan (2001) we extend the above literature into several directions. First, we introduce the term "Balkans stock markets" considering as a Balkan stock markets besides Greece and Turkey but Bulgaria, Romania, Croatia. We investigate common specifics of these markets analysing the dynamic linkages among Balkan stock markets to identify the main channels of information transmission. Third, we analyze the dynamic linkages among Balkans markets and Global markets. We would like to define the integration of the Balkan markets to the global markets. Fourth, we seek indications of benefit from portfolio diversification to the US dollar investors. We believe that if the Balkan markets have specifics comparing to the other regional markets, investing on Balkans will be a good opportunity for the foreign investors. But the main direction of our investigation is the possibility of integration of the Balkan markets. We try to figure out the co-integration between Balkan markets and their integration to the European and other global markets. We strongly believe in the future of the one integrated Balkan market and because of that we are confident that defining characteristics of the different Balkan markets can give possibilities for further integration between them.

## 3. Data and methodology

The study investigates the stock markets of Greece, Turkey and Romania. The data for Greece is from Morgan Stanley Capital International database, the index ISE 100 is from Istanbul Stock Exchange and the Romanian stock market index BET is from Bucharest Stock Exchange. The daily US dollar returns are analyzed for the period September 22, 1997 – May 31, 2002. The indexes of the other small Balkan markets (Sofia, Skopje, Belgrade and Sarajevo) are ignored because two reasons. First these indexes have been publicity available for a very short period to derive significant conclusions. Second, the market capitalization od some of them are so small that cannot be compared with other markets.

We use a Vector Auto Regressive (VAR) model to investigate whether Balkan stock markets behave like a single, integrated regional market. The VAR is suitable for the analysis of dynamic linkages among markets because it identifies the main channels of interactions and simulates the response of a given market to shocks in other markets. Each variable in VAR is treated as endogenous and is regressed on lagged values of all variables in the system. Shachmurove (1996) applies the following VAR specification analysing dynamic co-movement of Latin American stock markets:

$$Y(t) = C + \sum_{s=1}^{L} A(s) \cdot Y(t-s) + e(t) \qquad 1$$

where Y (t) is an nx1 vector of daily returns of stock markets, C is an nx1 vector of constants, A (s) is nxn matrices of coefficients, and e (t) is nx1 column-vector of forecast errors. The model assumes that e (t) is uncorrelated with all past values of Y(t). The i,j-th component of A (s) measures the direct effect that a change in the return of the j-th market would have on the i-th market in time periods.

To select appropriate lag length, following Thaneepanichskul (2001) we start from 15 lags and then reduce it to 10, lags, 5 lags, and 1 lag. We choose the optimal lag length on the basis of Akaike information criterion (AIC).

Most studies investigating the linkages among stock markets use Granger causality test. It determines whether a particular market is affected by innovations in other markets. The advantage of this test is that it is unaffected by the ordering of the VAR system. Granger test requires stationary data, so we apply both tests for unit root Augmented Dickey-Fuller  (ADF) test and Phillips-Perron (PP) test.

Variance decomposition and impulse response function are used to analyze the impact of innovations in a particular market on other markets. Variance decomposition of the forecast errors of the returns of a given market indicates the relative importance of the various markets in causing fluctuations in returns of that market. Variance decomposition allocates the variance of the forecast error into percentages that are accounted for by innovations in all market's own innovations. Variance decomposition is sensitive to the assumed origin of the shock and to the order in which it is transmitted to other markets. In this paper, the Global stock markets are ordered prior to the Balkan stock markets since we assume that shocks to a global markets have a strong impact on the Balkan stock markets.

Parallel with correlation of daily returns we analyze the residuals daily returns correlation for a VAR. The residuals daily returns represent are the component of the returns not explained by the past returns of all stock markets. The correlations indicate the extent of shared responses of all markets to new information in one market. Shachmurove (1996, 2001) use the correlations of residuals daily returns as an indicator for portfolio diversification since they measure the degree to which new information produces an abnormal return in one market is correlated by the other market.

## 4. Descriptive statistic

The Balkans can be clearly defined as a specific geographical, political and social part of Europe. Many economists have tried to describe the specifics of the economic system of this region and to define it as one of the specific economic region of Europe such as the Baltic, Iberian, Scandinavian or Central European countries.

This study is concentrated on Balkan stock markets. Our purpose is to find out if there are any common specifics of these markets. If such specifics exist we can prove that the Balkan markets should be accepted by the investors as one of the regional investment markets in Europe.

The basis in our study is the assumption that the Balkan stock markets have specific characteristics, which identify them in as a specific market region. We try to figure out that these specifics can create possibilities for portfolio diversification and in this way improve the risk-return characteristics of the investments.

As a first step we start with a comparison between Balkan stock markets and the most natural global benchmark markets for an American investor – US market, European market and World market. Let us assume the investment on Balkan stock market as an alternative to the most popular and efficient markets. Because of that an investor will start with such a comparison.

The results are presented in Table 1. It shows the descriptive statistics for the investigated markets – Greek, Turkish, Romanian, European, S&P500, World and Central European markets. In this section we compare Greece, Turkey and Romania on the one hand and Europe, S&P500 and World, on the other. The table shows very clearly several common features of the Balkan stock markets and strong differences among them and the three benchmark markets. The three Balkan stock markets have almost two times higher standard deviation than the standard deviation of the three global markets. The high standard deviation is the first sign of the high market risk. The results explain the big difference in the risk characteristics between Balkan markets and global developed markets. All authors investigating emerging markets have pointed out that this as a main specific of those markets.

Another difference between both market groups is high values for the kurtosis. In fact all the markets indicate non-normality of the return distributions. The kurtosis of the Balkan stock markets is much higher than those of the benchmark markets. The results from Table 1 are consistent with arguments of Bekaert, Erb, Harvey, and Viskanta (1998) that emerging markets are highly non-normal. Only for Greece we find the value for kurtosis near to that in Europe and World index.

For the skewness we find the same results. For the Romanian market there is positive skewness, but for Turkey and Greece the results show a negative one. If we compare the results of the values of the skewness of the benchmark markets we can see that the Balkan stock markets have the highest values for the skewness. Except for Turkey where the financial crisis led to a slightly negative skewness (with still a very low value (-0,17), compare to the global markets), the other Balkan stock markets present not so negative and even positive (in case of Romania) value for the skewness. This is in full contrast with the global markets where the skewness is highly negative (-0.23, -0.19 and -0.21 for Europe, S&P500 and World).

The results for the extreme values of the returns lead us to the same tendency – the Balkan stock markets appear to have the most extreme max and min of the returns. This is another proof of the much higher riskness of the Balkan stock markets as typical emerging markets. The mean returns of the three Balkan stock markets are negative while of the Europe, S&P500 and World - positive. Although it is hard to make any final conclusions based only on these indexes it is clear that during the study period the situations and tendency of two group markets have been absolutely different. We can resume: The Balkan markets have typical for the emerging markets high standard deviation, high kurtosis, high extreme values for the returns, mean value of the return different from the global market tendency.

To the same results leads us the numbers of the correlation matrix between studied markets. Our results are fully consisting with Harvey (1995a) and describe very small correlation between Balkan markets from one side and global markets from other. In the same direction Erb, Harvey, Viskanta (1998) prove that emerging markets are very low correlated with the world or other global markets. We find the same results for Greece, Turkey and Romania. The correlation matrix of the Balkan markets is presented in Table 2. Only Greece and Turkey have a correlation higher than 0,15 with EU. Greece has 0,33 correlation coefficient with Europe and Turkey has 0,24 coefficient with Europe. We think this is somehow natural if we take into account that Greece is a member of EU and Turkey is highly integrated to European economy. But for all other cases we found a very low correlation between global benchmark markets and Balkan markets. This result leads us to two major conclusions. From one point of view, we again can prove that the characteristics of the Balkan markets are the same as for all the other Emerging markets. From another point of view, the low correlation between Balkan and global markets creates opportunities for portfolio diversifications. We take these results as a starting point for quantifying the portfolio diversification possibilities for the investors.

As a next step in our study we compare the risk-return characteristics of the Balkan market with those of the Central European market[2]. The Central European

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[2] The Central European stock markets are represented by the CESI index. The index reflects market price movements of stocks traded at five stock exchanges in the Central European region. CESI is a US dollar based capitalization weighted stock index with a basis of 1000 points, the basket of the index comprising selected papers from five stock exchanges (Budapest, Prague, Warsaw, Ljubljana and Bratislava). The calculation of the index uses daily average market prices for Budapest, Ljubljana and Bratislava and the daily fixing rate as it develops through equilibrium price based trading in Warsaw and Prague.

market is the only one really accepted by the investors as a regional market in Europe with characteristics of an emerging market. We try to find if there are differences between both regional emerging markets in Europe. If such differences exist we could be able to achieve more attractive risk-return characteristics for a portfolio involving investments on the Balkan market. If there are not so big differences in the characteristics of Central European and Balkan markets, an investor will not be interested in portfolio diversification.

The fourth column of the Table1 presents the same descriptive statistic for the Central European stock markets. The results are very interesting. We prove that the Central European market still has characteristics of the emerging markets, but it looks more like a European than a Balkan market. This result can be describe as follows:

On the one hand some of the indexes of the Central European market are in the same amplitude as of the Balkan markets - the values for the mean returns and extreme returns. From the other hand some indexes describe Central Europe as a global market – the skewness is highly negative just as for the all from the group of global markets. Still on the other hand side the value of standard deviation of the Central Europe is exactly in the middle between the two groups.

The specifics of the Central and Eastern Europe as the market with characteristics separating it in a specific group between Balkan and global markets can be proved also by correlation matrix. Table 2 presents correlation of Central and Eastern Europe with the other global markets. In contrast with Balkan markets, Central Europe has correlation coefficient above 0,15. Of course, the coefficient is still lower that those between global markets, but cannot be compared with coefficients between Balkan and global markets.

We describe the Central and Eastern European market as the market combining the characteristics of the emerging markets and developed markets. The fast market reforms in the Central European countries and the intensive process of integration to the European Union give more global aspects of this market.

In conclusion for this part of our study we can summarize that the Balkan markets can be treated as typical emerging markets. Something more, we think that this region is the only one in Europe with the characteristics of the emerging markets. Investors in the other markets in Central and Eastern Europe do not meet the risk-return characteristics of the typical emerging markets. This means that US dollar investors can use the specifics of these markets for portfolio diversification.

## 5. Inter-Balkan stock markets integration

Table 3 presents both tests for unit root the Augmented Dickey-Fuller test with four lags and Phillips – Perron test with six lags and MacKinon critical values (Enders 1995). The results supports the hypothesis that Balkan stock markets are first–order integrated I(1). Thus, we can run Granger causality test Granger causality test of Granger (1969) in order to assess the co-movements among the Balkan markets. The null hypothesis is that innovations in one market cannot help forecast a one-step ahead return in another market.

Table 4 presents the results from Granger causality test with 1 lag. Results indicate that we cannot reject the null hypotheses. Thus, particular Balkan stock market is not affected by innovations in other Balkan stock markets. Contrary to Drakos and Kutan (2001) we do not reject the null hypothesis that Turkish stock market dose not Granger cause Greek stock market. Possible explanation of that difference in results could be the specifics of analyzed data since Garnger causality test is sensitive to time series properties (e.g. lag length). Drakos and Kutan (2001) analyze monthly values of Istanbul Stock Exchange and Athens Stock Exchange indexes over the period November 1988 – December 2000 (148 observations) while we analyze daily values of stock market indexes over the recent period September 22 1997-May 31 2002 (1225 observations).

Results from Vector Autoregression (Table 5) argue that Balkan stock markets do not behave like a single, integrated regional market. Both Greek and Romanian stock markets are influenced only by their own lags.

Table 6 shows results of the variance decomposition of Balkan stock markets. Greece seems most independent stock market since only 0.052 percents of its variance of forecasted errors are explained by other Balkan stock markets. Next independent stock market is Romania. About 0.20 percents of its variance is explained by other markets. Turkey seems is more affected by Greece. Greece explains about 3.44 percents of the variance of Turkey.

Table 7 presents interesting results. Correlations of residuals daily returns for Balkan markets for a VAR with 1 lag are relatively low for geographically close markets. The correlation coefficient of residual returns between Greece and Turkey is 0.1834 while the correlation coefficient between Turkey and Romania is negative (-0.0135).

Our findings from Granger causality test, Vector Autoregression and Variance decomposition argue that Balkan stock markets do not behave like a single, integrated regional market. Furthermore, there exists a benefit from future portfolio diversification. From other side we believe that using these portfolio possibilities from investors will lead the markets to one more integrated level.

## 6. Integration of the Balkan markets to the global markets

In this section we investigate the relationship between Balkan stock markets and Global stock markets. We consider four global stock markets: World (MSCI World excluding USA), US (S&P 500), Europe (MSCI Europe), and Central and Eastern European (CESI index).

The results presented in Table 3 argue that considered Global stock markets are first–order integrated I(1). Thus, we can run Granger causality test of Granger (1969) in order to assess the co-movements among Balkan markets and Global markets.

Table 8 presents the results from Granger causality test with 15 lags of daily returns of Balkan stock markets and Central and Eastern European Results indicate that we can reject the null hypotheses Central and Eastern Europe does not Granger Cause Greece at 5% significance level. Thus, Greek stock market is affected by innovations in Central and Eastern European stock markets. Since we do not find significant transmissions of shocks from Central and Eastern Europe to Turkey and Romania and vice versa we can conclude that Balkan stock markets are relatively independent from Central and Eastern European stock markets. This fact is confirmed by the results of the variance decomposition for Central and Eastern European and Balkan stock markets (Table 9). Romania seems most independent stock market since only 0.19 percents of its variance of forecasted errors are explained by other stock markets. Next independent stock market is Greece. Other markets, mainly Central and Eastern Europe, explain about 0.60 percents of its variance. Turkey is more affected by Greece. Greece explains about 3.20 percents of the variance of Turkey. Central and Eastern European markets is more affected by Greece followed by Turkey. Both markets explain about 18 percents of the variance of Central and Eastern Europe.

Table 10 presents correlations of residuals daily returns for Central and Eastern European and Balkan markets for a VAR with 15 lags. The correlation coefficients between Greece and Central Europe and between Turkey and Central Europe are relatively high for markets different from both geographical and economic point of view. It is interesting to note that Turkey has higher correlation with CEE (0.2923) than correlation with Greece (0.1773). Romania holds up low correlations with Greece and Central and Eastern Europe and negative correlation with Turkey.

Balkan stock markets are affected by European market (Table 11). European stock market Granger cause both Greece and Turkey at 1% significance level. Moreover, we observe bi- directional causality between Europe and Turkey. Romania remains unaffected from Europe. Thus, we can conclude that Balkan stock markets are relatively dependent from European stock market. Theses findings are confirmed by the results of the variance decomposition for European and Balkan stock markets (Table 12). European market explain about 15 percents of the variance of Greece and 7 percent of the variance of Turkey. Romania is most independent stock market since only 0.20 percents of its variance of forecasted errors are explained by other stock markets. European stock market is independent from Balkan market. Balkan stock markets explain only 0.11 percents of Europe.

Table 13 presents correlations of residuals daily returns for European market and Balkan markets for a VAR with 15 lags. The correlation coefficient between Greece and EU is relatively low for close markets from both geographical and economic point of view. Romania has negative correlations with Turkey and Europe and positive but close to zero correlation with Greece which is an indication for opportunities for portfolio diversification.

Table 14 presents Granger causality test with 15 lags of daily returns of S&P 500 and Balkan stock markets. Results shows that S&P 500 stock market Granger causes both Greece and Turkey at 1% significance level. Romania remains unaffected from S&P 500.

Table 15 presents results of variance decomposition for S&P 500 and Balkan stock markets. S&P 500 explains about 7 percents of the variance of Greece and 6 percent of the variance of Turkey. Romania is independent stock market since only 0.14 percents of its variance of forecasted errors are explained by other stock markets. As we can expect S&P 500 is independent from Balkan market. Balkan stock markets explain only 0.30 percents of the variance of S&P 500.

Table 16 presents correlations of residuals daily returns for S&P 500 and Balkan markets for a VAR with 15 lags. The correlation coefficients between S&P 500 and Balkan markets are low.

Table 17 presents Granger causality test with 15 lags of daily returns of World market and Balkan stock markets. Results shows that World market Granger causes both Greece and Turkey at 1% significance level. Romania remains unaffected from innovations of the World market.

Table 18 presents results of variance decomposition for S&P 500 and Balkan stock markets. World market explains about 10 percents of the variance of Greece and 7 percent of the variance of Turkey. Romania is not affected by World market since only 0.16 percents of its variance of forecasted errors are explained by other stock markets. Balkan stock markets explain only 0.30 percents of the variance of World market.

Table 19 presents correlations of residuals daily returns for World market and Balkan markets for a VAR with 15 lags. The correlation coefficients between World market and Balkan markets are low. Both Turkey and Greece have equal correlation coefficient with World market (0.22) while the correlation coefficient between Romania and World market is close to zero.

The above findings lead us to infer that Balkan stock markets are partially integrated into the global markets. Greece is most integrated stock market among Balkan markets. Romania is most fragmented stock market. It is not affected by innovations of Global stock markets. We describe the Balkans as one specific market influenced by the global markets. Further development of the Balkan markets will lead to more integrative behavior of the market. This relationship can be observed if we compare the less and the most developed market – Romania and Greece respectively.

## 7. Risk characteristics of Balkan Stock Markets

A variety of papers examine the international version of the Capital Asset Pricing Model, proposed by Sharpe (1964). If international capital markets are integrated, the expected return of a security ***i*** can be written in terms of the International Capital Asset Pricing Model as:

$$\left(r_i - r_f\right) = \beta_i \left(r_m - r_f\right)$$
$$\beta_i = \frac{\text{cov}\left(r_i, r_m\right)}{\sigma_m^2}$$

where $r_i$ is the expected return on asset $i$, $r_f$ is a world wide risk-free interest rate, $r_w$ is the expected return of a global market portfolio. Frequently, researchers use MSCI World index as a proxy of global market portfolio. In the empirical tests of the model used in the literature are based on the following regression:

$$R_i = \alpha + \beta R_w + e_i \qquad e_i \sim N\left(0, \sigma^2\right) \qquad 2$$

where $R_i$ is the excess return on the market $i$, $R_w$ is the global market portfolio return.

Results for International Capital Asset Pricing Model estimates from Equation 1 are presented in Table 20. Beta estimates are significant for Greece and Turkey. The beta coefficient of Romania is positive but close to zero and insignificant. Possible explanations of that result are (1) the stocks in BET index traded infrequently and (2) the Romanian stock market is not integrated into the world capital market. The beta estimate of Turkey is higher than the beta estimates of Greece, which indicates that Turkey has higher market risk than Greece. The three markets have negative but insignificant alpha estimate.

Since Chortareas et al. (2000), Balaban (1995a, 1995b) and Codirlaşu (2000) document significant conditional heteroscedasticity in Greece, Turkey and Romania, respectively we employ two tests for autoregressive conditional heteroscedasticity in the residuals of the standard International Capital Asset Pricing Model. The first test is the Box-Ljung Q-statistics on the autocorrelation of the squared residuals series. The second one is the Engle's (1982) test of ARCH effect in residuals. Both tests reject the null hypothesis of no conditional heteroscedasticity at the 1% significance level. Since the standard International Capital Asset Pricing Model assumes that residuals are iid normal distributed we employ Box-Ljung Q-statistics at lag 1 to test the nul hypothesis of no first-order autocorrelation in the residuals series and Jarque-Bera test statistics for null hypothesis of normality of the residuals. We reject both null hypotheses at 1% significance. Thus, the parameters of the Equation 2 are not efficient and test statistics are inconsistent.

Engle (1982), Bollerslev (1986) and Nelson (1991) propose ARCH family models to modeling the time-varying risk premium. One of the most used ARCH models in international asset pricing is GARCH (1,1) model with following specification:

$$R_i = \alpha + \beta R_w + e_t \qquad e_t | I_{t-1} \sim N(0, h_t) \qquad 3$$

$$h_t = \omega + \alpha_1 e_{t-1}^2 + \beta_1 h_{t-1}$$

where $e_t$ errors conditional to the information set $I_{t-1}$ follow normal distribution with mean zero and variance $h_t$.

Results of the conditional international capital asset pricing model indicate positive and significant beta estimates of Greece and Turkey and negative but insignificant beta estimate of Romania (Table 21). Turkey keeps higher market risk comparing with Greece. Notwithstanding, Greece has higher volatility persistence coefficient $(\alpha_1 + \beta_1) = 0.9236$ than Turkey (0.8605). Romania has lowest volatility persistence coefficient - 0.7419. The large ARCH coefficient and low GARCH coefficient of Romania means that the volatility is very spiky which is an indicator that normal distribution should be replaced by a fat-tailed conditional distribution for residuals, $e_t$. Turkey has highest unconditional volatility 0.001434 followed by Greece 0.000393 and Romania 0.000387. The large persistence in volatility of Greece indicates low speed of converges of the conditional volatility to the unconditional volatility. Both Box-Ljung Q-statistics on the autocorrelation of the squared residuals series and Engle's test of ARCH effect in residuals do not reject the null hypothesis of no conditional heteroscedasticity.

The Jarque-Bera test statistics of normality of standardized residuals rejects the null hypothesis of normality at 1% significance – Table 21. Thus, the GARCH (1,1) with normal distributed errors would be likely to underestimate risk. To avoid this underestimation we use GARCH (1,1) model with t – distributed errors, proposed by Bollerslev (1987). Applied to international capital asset pricing model the GARCH (1,1) – t model has following specification:

$$R_i = \alpha + \beta R_w + e_t \qquad e_t = \sqrt{h_t} u_t \qquad u_t \sim t(0,1,\nu) \qquad 4$$

$$h_t = \omega + \alpha_1 e_{t-1}^2 + \beta_1 h_{t-1}$$

where $u_t$ is iid Student – t distributed random variable with mean zero variance one, and $\nu$ degree of freedom.

Results presented in Table 22 indicate positive and significant beta estimates of Greece and Turkey and negative but insignificant beta estimate of Romania. Turkey keeps highest market risk while Greece keeps highest volatility persistence among Balkan stock markets.

We employ Kolmogorov-Smirnov test statistics of null hypothesis that the data are from a specified distribution in order to determine if GARCH (1,1) – t is appropriate model in compare with GARCH (1,1) with normal distributed residuals. The results indicate that GARCH (1,1) – t model is suitable for modeling all three Balkan stock markets (Table 23).

Numerous researchers have found that changes in stock prices tend to be negatively related with changes in stock volatility. This phenomenon is known as a “leverage effect”. Nelson (1991) purposes the Exponential GARCH for modeling the “leverage effect”. The EGARCH (1,1) is widely used specification of and applied to international capital asset pricing model the model has following form:

$$
\begin{aligned}
&R_i = \alpha + \beta R_w + e_t \\
&e_t \sim N(0,1) \qquad\qquad (5)\\
&\ln h_{it}^2 = \omega + \gamma_1\left(\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \alpha_1 \frac{e_{t-1}}{\sqrt{h_{t-1}}} + \beta_1 \ln\left(h_{t-1}^2\right)
\end{aligned}
$$

where $R_i$ is the excess return on the market *i*, $R_w$ is the global market portfolio return, $e_t$ errors conditional to the information set $I_{t-1}$ follow normal distribution with mean zero and variance $h_t$, $\omega$, $\gamma_1$, $\alpha_1$, $\beta_1$ are parameters of variance equation. The parameter $\gamma_1$ measures the impact if the residual, $e_t$, on conditional volatility at time t. The parameter $\alpha_1$ measures the asymmetric response of conditional variance to residuals. If the parameter is negative (positive), then negative realizations of the residuals generate more (less) volatility than do positive realizations.

Table 24 presents the results of estimation of Equation 5. They indicate significant and positive beta estimates of Greece and Turkey. Romanian beta estimates is also positive but insignificant. The parameter $\alpha_1$ is negative for all three markets but significant at 10% level only for Turkey. Both Box-Ljung Q-statistics on the autocorrelation of the squared residuals series and Engle’s test of ARCH effect in residuals do not reject the null hypothesis of no conditional heteroscedasticity.

The Jarque-Bera test statistics of normality of standardized residuals rejects the null hypothesis of normality at 1% significance. Thus, to capture the heavy-tails in data series we employ the classical EGARCH model of Nelson (1991) with GED distributed residuals. The model has following specification:

$$
\begin{aligned}
&R_i = \alpha + \beta R_w + e_t \\
&e_t \sim GED(0,1,\nu) \\
&\ln h_{it}^2 - \zeta_t = \alpha_1 \eta_{t-1} + \beta_1 \left(\ln\left(h_{t-1}^2\right) - \zeta_{t-1}\right) \\
&\eta_{t-1} = \left(\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \chi_1 \frac{e_{t-1}}{\sqrt{h_{t-1}}}, \;\; \zeta_t = \zeta + \ln(1 + \rho N_t)
\end{aligned}
\tag{6}
$$

where $R_i$ is the excess return on the market $i$, $R_w$ is the global market portfolio return, $e_t$ errors conditional to the information set $I_{t-1}$ follow generalized error distribution with mean zero and variance $h_t$, and $\nu$, $\zeta_t$, $\zeta$, $\chi_1$, $\rho$, $\alpha_1$, $\beta_1$ are parameters of the variance equation, $N_t$ number of non-trading days between t and t-1.

Table 25 presents the results of estimation of Equation 6. They indicate significant and positive beta estimates of Greece and Turkey. Romanian beta estimates is negative and insignificant. The parameter $\chi_1$ is negative for three markets but significant for Greece and Turkey. Thus, significant "leverage effect" is found only for Greece and Turkey, which means a greater impact of negative shock to Greek and Turkish stock market volatility. More specifically, the volatility is higher during market declines than market booms. Greece has highest volatility persistence (0.9129) among Balkan stock markets. Kolmogorov-Smirnov test statistics of null hypothesis that the data are from a specified distribution indicates that EGARCH (1,1) with generalized error distributed residuals captures both the "leverage effect" and fat-tailed residuals (Table 26).

## 8. Conclusion

The study investigates the stock markets of Greece, Turkey and Romania. The basis of the paper is the assumption that the Balkan stock markets have specific characteristics, which divide them in a specific market region. The research derives the basic characteristics: (1) the Balkan stock markets are typical emerging markets; (2) the Balkan stock markets can give additional diversification opportunities to the investors since they are not affected by innovations of major developed stock markets. Our findings from Granger causality test, Vector Autoregression and Variance decomposition argue that Balkan stock markets do not behave like a single, integrated regional market. Furthermore, there exists a benefit from future portfolio diversification.

Appling International Capital Asset Pricing Model we found out that beta estimates are significant for Greece and Turkey. The beta coefficient of Romania is close to zero and insignificant due to the fact that Romanian stock market is not integrated into the world capital market. The beta estimate of Turkey is higher than the beta estimates of Greece, which indicates that Turkey has higher market risk than Greece. The three markets have negative but insignificant alpha estimate.

We argue significant conditional heteroscedasticity in Greece, Turkey and Romania, in the residuals of the standard International Capital Asset Pricing Model. To achieve more precise results we applied to international capital asset pricing model the GARCH (1,1) – t model. Results indicate positive and significant beta estimates of Greece and Turkey and negative but insignificant beta estimate of Romania. Turkey keeps highest market risk while Greece keeps highest volatility persistence among Balkan stock markets. The results indicate that GARCH (1,1) – t model is more suitable for modeling all three Balkan stock markets among GARCH models.

Our investigation found significant “leverage effect” for Greece and Turkey, which means a greater impact of negative shock to Greek and Turkish stock market volatility. More specifically, the volatility is higher during market declines than market booms. We prove that EGARCH (1,1) with generalized error distributed residuals captures both the “leverage effect” and fat-tailed residuals.

Our study describes Balkan markets as uncorrelated, uninfluenced each other and with unequal risk characteristics. This is especially evidently for Romania. This market is fully non-integrated. For the two big markets in the region we found that they can be described as being in the beginning of process of integration. We think that this can be described as the beginning of forming the future integrated Balkan market. Using existing portfolio opportunities by investors will develop more integration between local markets and will lead to establishing well developed integrated emerging markets on the Balkans.

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Table 1. Descriptive statistics of stock markets

| | Greece | Turkey | Romania | CEE | EU | S&P 500 | World |
|---|---|---|---|---|---|---|---|
| Mean | -0,0163% | -0,0584% | -0,1030% | -0,0253% | 0,0021% | 0,0083% | 0,0001% |
| Median | 0,0000% | 0,0000% | -0,0622% | 0,0200% | 0,0448% | 0,0000% | 0,0333% |
| Maximum | 8,4342% | 18,7812% | 10,0113% | 6,3133% | 5,0082% | 4,9887% | 3,6773% |
| Minimum | -9,8499% | -23,6661% | -10,4884% | -9,4592% | -5,6814% | -7,1127% | -4,5212% |
| Std, Dev, | 2,1436% | 3,9675% | 1,9987% | 1,5621% | 1,1679% | 1,2686% | 0,9614% |
| Skewness | -0,0520 | -0,1712 | 0,0743 | -0,4091 | -0,2351 | -0,1991 | -0,2164 |
| Kurtosis | 4,8871 | 6,9996 | 7,3845 | 6,1602 | 4,5036 | 5,7790 | 4,4032 |
| Jarque-Bera | 181,2839* | 817,7867* | 976,7230* | 540,8238* | 125,9461* | 399,9789* | 109,4340* |
| Probability | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| First-order AC | 0,1340* | 0,0420 | 0,2980* | 0,1770* | 0,0820* | -0,0110 | 0,1740* |
| Q-Stat | 21,9410 | 2,1072 | 108,6600 | 38,3280 | 8,3328 | 0,1411 | 37,0540 |
| Prob | 0,0000 | 0,1470 | 0,0000 | 0,0000 | 0,0040 | 0,7070 | 0,0000 |
| Observations | 1218 | 1218 | 1218 | 1218 | 1218 | 1218 | 1218 |

* denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 2. Correlation matrix of daily returns

| | Greece | Turkey | Romania | CEE | EU | S&P 500 | World |
|---|---|---|---|---|---|---|---|
| Greece | 1 | 0,1857 | 0,0248 | 0,3678 | 0,3312 | 0,1057 | 0,2582 |
| Turkey | 0,1857 | 1 | -0,0011 | 0,3028 | 0,2460 | 0,1452 | 0,2368 |
| Romania | 0,0248 | -0,0011 | 1 | 0,0609 | -0,0066 | 0,0075 | 0,0006 |
| CEE | 0,3678 | 0,3028 | 0,0609 | 1 | 0,5187 | 0,1706 | 0,4135 |
| EU | 0,3312 | 0,2460 | -0,0066 | 0,5187 | 1 | 0,4143 | 0,7531 |
| S&P 500 | 0,1057 | 0,1452 | 0,0075 | 0,1706 | 0,4143 | 1 | 0,8751 |
| World | 0,2582 | 0,2368 | 0,0006 | 0,4135 | 0,7531 | 0,8751 | 1 |

Table 3. Tests for unit root on the log levels and first differences of the stock market indexes

| **Panel A. Log Levels** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Greece | Turkey | Romania | CEE | EU | SP | W | Critical Values ‡ |
| ADF (I) | -0,883 | -1,421 | -2,649 | -2,225 | -1,718 | -1,998 | -1,477 | -3,439 |
| ADF (T &I) | -1,361 | -1,666 | -1,045 | -2,395 | -2,024 | -1,572 | -1,391 | -3,971 |
| ADF (none) | -0,353 | -0,613 | -1,443 | -0,441 | -0,009 | 0,266 | -0,005 | -2,567 |
| PP (I) | -0,924 | -1,357 | -2,850 | -2,164 | -1,767 | -1,964 | -1,453 | -3,439 |
| PP (T & I) | -1,421 | -1,638 | -1,000 | -2,287 | -2,079 | -1,558 | -1,356 | -3,971 |
| PP (none) | -0,304 | -0,587 | -1,630 | -0,467 | 0,043 | 0,235 | 0,008 | -2,567 |
| **Panel B. First differences** | | | | | | | | |
| ADF (I) | -15,590* | -15,975* | -14,097* | -15,278* | -16,318* | -16,785* | -16,162* | -3,439* |
| ADF (T & I) | -15,666* | -15,979* | -14,369* | -15,286* | -16,387* | -16,883* | -16,244* | -3,971* |
| ADF (none) | -15,593* | -15,970* | -14,041* | -15,278* | -16,325* | -16,789* | -16,169* | -2,567* |
| PP (I) | -30,469* | -33,375* | -25,780* | -29,142* | -32,061* | -35,445* | -29,060* | -3,439* |
| PP (T & I) | -30,511* | -33,373* | -25,917* | -29,137* | -32,103* | -35,515* | -29,095* | -3,971* |
| PP (none) | -30,481* | -33,382* | -25,757* | -29,151* | -32,075* | -35,458* | -29,073* | -2,567* |

ADF – Augmented Dickey – Fuller Test with 4 lags. PP – Phillips – Perron Test with 6 lags

* denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

‡ denotes 1% MacKinon Critical values.

I denotes intercept, T & I denote trend &intercept

Table 4. Granger causality test with 1 lag of daily returns of Balkan stock markets

| Null Hypothesis: | F-Statistic |
|---|---|
| Turkey does not Granger Cause Greece | 0.09614 |
| Greece does not Granger Cause Turkey | 0.68268 |
| Romania does not Granger Cause Greece | 0.59931 |
| Greece does not Granger Cause Romania | 0.00361 |
| Romania does not Granger Cause Turkey | 1.40290 |
| Turkey does not Granger Cause Romania | 1.89875 |

* denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 5. Vector Auto Regression with 1 lag of daily returns of Balkan stock markets

| | Greece | Turkey | Romania |
|---|---|---|---|
| Greece (-1) | 0.135192* | 0.043065 | -0.008498 |
| | (4.66616) | (0.79666) | (-0.32686) |
| Turkey (-1) | -0.004783 | 0.037318 | 0.019872 |
| | (-0.30544) | (1.27726) | (1.41421) |
| Romania (-1) | 0.023547 | 0.066290 | 0.298319* |
| | (0.77126) | (1.16373) | (10.8889) |
| C | -9.53E-05 | -0.000494 | -0.000688 |
| | (-0.15588) | (-0.43342) | (-1.25423) |
| R-squared | 0.018552 | 0.003405 | 0.090453 |
| Adj. R-squared | 0.016121 | 0.000936 | 0.088200 |
| Sum sq. resids | 0.548340 | 1.908861 | 0.441538 |
| S.E. equation | 0.021279 | 0.039702 | 0.019095 |
| F-statistic | 7.630390 | 1.379257 | 40.14395 |
| Log likelihood | 2955.780 | 2198.005 | 3087.384 |
| Akaike AIC | -4.858898 | -3.611531 | -5.075528 |
| Schwarz SC | -4.842099 | -3.594733 | -5.058730 |
| Mean dependent | -0.000139 | -0.000590 | -0.001003 |
| S.D. dependent | 0.021453 | 0.039721 | 0.019997 |
| Determinant Residual Covariance | | 2.49E-10 | |
| Log Likelihood | | 8262.350 | |
| Akaike Information Criteria | | -13.58082 | |
| Schwarz Criteria | | -13.53043 | |

Note: t-statistics in parentheses. * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 6. Variance decomposition for Balkan stock markets

| Variance Decomposition of Greece: | | | | |
|---|---|---|---|---|
| Period | S.E. | Greece | Turkey | Romania |
| 2 | 0.021439 | 99.94800 | 0.008195 | 0.043809 |
| 10 | 0.021444 | 99.93924 | 0.008259 | 0.052501 |
| Variance Decomposition of Turkey: | | | | |
| 2 | 0.039701 | 3.445914 | 96.45283 | 0.101252 |
| 10 | 0.039704 | 3.447276 | 96.43768 | 0.115045 |
| Variance Decomposition of Romania: | | | | |
| 2 | 0.019904 | 0.033591 | 0.142637 | 99.82377 |
| 10 | 0.019987 | 0.033434 | 0.156318 | 99.81025 |

Note: Ordering: Greece Turkey Romania

Table 7. Correlation matrixes of residuals daily returns for a VAR with 1 lag

| | Residual Greece | Residual Turkey | Residual Romania |
|---|---|---|---|
| Residual Greece | 1.000000 | 0.183411 | 0.018774 |
| Residual Turkey | 0.183411 | 1.000000 | -0.013454 |
| Residual Romania | 0.018774 | -0.013454 | 1.000000 |

Table 8 Granger causality test with 15 lags of daily returns of Balkan stock markets and CEE

| Null Hypothesis: | F-Statistic |
|---|---|
| CEE does not Granger Cause Greece | 1.69026** |
| Greece does not Granger Cause CEE | 0.37276 |
| CEE does not Granger Cause Turkey | 1.28561 |
| Turkey does not Granger Cause CEE | 1.34272 |
| CEE does not Granger Cause Romania | 1.36878 |
| Romania does not Granger Cause CEE | 1.18092 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 9. Variance decomposition for CEE and Balkan stock markets

| Variance Decomposition of Greece:: | | | | | |
|---|---|---|---|---|---|
| Period | S.E. | Greece | Turkey | Romania | CEE |
| 2 | 0.021155 | 99.40795 | 0.049240 | 0.012973 | 0.529836 |
| 10 | 0.021444 | 97.38030 | 0.421464 | 0.471000 | 1.727231 |
| Variance Decomposition of Turkey: | | | | | |
| 2 | 0.038898 | 3.239948 | 96.58900 | 0.103759 | 0.067294 |
| 10 | 0.039552 | 4.126785 | 94.68835 | 0.491478 | 0.693387 |
| Variance Decomposition of Romania: | | | | | |
| 2 | 0.019498 | 0.018259 | 0.142628 | 99.81870 | 0.020415 |
| 10 | 0.019805 | 0.624241 | 0.346417 | 97.19866 | 1.830687 |
| Variance Decomposition of CEE: | | | | | |
| 2 | 0.015259 | 12.86677 | 5.408610 | 0.621090 | 81.10353 |
| 10 | 0.015504 | 12.91765 | 6.450508 | 1.202949 | 79.42890 |

Note: Ordering: Greece Turkey Romania CEE

Table 10 Correlation matrixes of residuals daily returns for a VAR with 15 lags

| | Residual Greece | Residual Turkey | Residual Romania | Residual CEE |
|---|---|---|---|---|
| Residual Greece | 1.000000 | 0.177330 | 0.002663 | 0.359344 |
| Residual Turkey | 0.177330 | 1.000000 | -0.034066 | 0.292260 |
| Residual Romania | 0.002663 | -0.034066 | 1.000000 | 0.010948 |
| Residual CEE | 0.359344 | 0.292260 | 0.010948 | 1.000000 |

Table 11 Granger causality test with 15 lags of daily returns of European and Balkan stock markets

| Null Hypothesis: | F-Statistic |
|---|---|
| Greece does not Granger Cause EU | 1.24273 |
| EU does not Granger Cause Greece | 4.39191* |
| Turkey does not Granger Cause EU | 1.94781** |
| EU does not Granger Cause Turkey | 2.81269* |
| Romania does not Granger Cause EU | 1.21448 |
| EU does not Granger Cause Romania | 0.86423 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 12. Variance decomposition for European and Balkan stock markets

| Variance Decomposition of EU: | | | | | |
|---|---|---|---|---|---|
| Period | S.E. | EU | Greece | Turkey | Romania |
| 2 | 0.011316 | 99.89843 | 0.059827 | 0.002527 | 0.039217 |
| 10 | 0.011646 | 96.46626 | 1.343512 | 1.566059 | 0.624164 |
| Variance Decomposition of Greece: | | | | | |
| 2 | 0.020954 | 13.69861 | 85.87218 | 0.405096 | 0.024113 |
| 10 | 0.021364 | 14.42730 | 84.01854 | 1.006755 | 0.547403 |
| Variance Decomposition of Turkey: | | | | | |
| 2 | 0.038530 | 6.210889 | 0.876392 | 92.82130 | 0.091421 |
| 10 | 0.039423 | 7.706695 | 1.840223 | 90.03255 | 0.420529 |
| Variance Decomposition of Romania: | | | | | |
| 2 | 0.019616 | 0.031867 | 0.050123 | 0.112317 | 99.80569 |
| 10 | 0.019820 | 0.540134 | 0.778898 | 0.376098 | 98.30487 |

Note: Ordering: EU Greece Turkey Romania

Table 13 Correlation matrixes of residuals daily returns for a VAR with 15 lags

| | Residual EU | Residual Greece | Residual Turkey | Residual Romania |
|---|---|---|---|---|
| Residual EU | 1.000000 | 0.313893 | 0.239053 | -0.014881 |
| Residual Greece | 0.313893 | 1.000000 | 0.164163 | 0.014878 |
| Residual Turkey | 0.239053 | 0.164163 | 1.000000 | -0.027667 |
| Residual Romania | -0.014881 | 0.014878 | -0.027667 | 1.000000 |

Table 14 Granger causality test with 1 lag of daily returns of S&P 500 and Balkan stock markets

| Null Hypothesis: | F-Statistic |
|---|---|
| Greece does not Granger Cause S&P 500 | 1.41476 |
| S&P 500 does not Granger Cause Greece | 5.76993* |
| Turkey does not Granger Cause S&P 500 | 1.54912*** |
| S&P 500 does not Granger Cause Turkey | 4.42755* |
| Romania does not Granger Cause S&P 500 | 1.08722 |
| S&P 500 does not Granger Cause Romania | 0.97146 |
| Turkey does not Granger Cause Greece | 0.82644 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 15 Variance decomposition for S&P 500 and Balkan stock markets

| Variance Decomposition of S&P 500: | | | | | |
|---|---|---|---|---|---|
| Period | S.E. | S&P 500 | Greece | Turkey | Romania |
| 2 | 0.012397 | 99.69279 | 0.113437 | 0.177774 | 0.015996 |
| 10 | 0.012678 | 96.15062 | 1.169243 | 1.680649 | 0.999488 |
| Variance Decomposition of Greece: | | | | | |
| 2 | 0.021133 | 7.507971 | 92.04381 | 0.405776 | 0.042440 |
| 10 | 0.021430 | 8.371580 | 90.25519 | 0.789404 | 0.583823 |
| Variance Decomposition of Turkey: | | | | | |
| 2 | 0.038914 | 6.214754 | 1.463184 | 92.21716 | 0.104903 |
| 10 | 0.039549 | 6.702262 | 2.275167 | 90.59052 | 0.432046 |
| Variance Decomposition of Romania: | | | | | |
| 2 | 0.019538 | 0.004647 | 0.022737 | 0.109457 | 99.86316 |
| 10 | 0.019827 | 0.643409 | 1.436339 | 0.444255 | 97.47600 |

Note: Ordering: S&P 500 Greece Turkey Romania

Table 16 Correlation matrixes of residuals daily returns for a VAR with 15 lags

| | Residual S&P 500 | Residual Greece | Residual Turkey | Residual Romania |
|---|---|---|---|---|
| Residual S&P 500 | 1.000000 | 0.111972 | 0.141188 | 0.002964 |
| Residual Greece | 0.111972 | 1.000000 | 0.137843 | 0.015973 |
| Residual Turkey | 0.141188 | 0.137843 | 1.000000 | -0.024438 |
| Residual Romania | 0.002964 | 0.015973 | -0.024438 | 1.000000 |

Table 17 Granger causality test with 15 lag of daily returns of World market and Balkan stock markets

| Null Hypothesis: | F-Statistic | Probability |
|---|---|---|
| Greece does not Granger Cause World | 1.36858 | 0.15485 |
| World does not Granger Cause Greece | 5.92132* | 5.3E-12 |
| Turkey does not Granger Cause World | 1.52239*** | 0.08984 |
| World does not Granger Cause Turkey | 4.44192* | 3.3E-08 |
| Romania does not Granger Cause World | 1.18062 | 0.28018 |
| World does not Granger Cause Romania | 0.88718 | 0.57868 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 18 Variance decomposition for World market and Balkan stock markets

| Variance Decomposition of World: | | | | | |
|---|---|---|---|---|---|
| Period | S.E. | World | Greece | Turkey | Romania |
| 2 | 0.009360 | 99.71359 | 0.041506 | 0.244703 | 0.000196 |
| 10 | 0.009597 | 95.89134 | 1.503006 | 1.889311 | 0.716343 |
| Variance Decomposition of Greece: | | | | | |
| 2 | 0.021004 | 10.54011 | 88.86234 | 0.548111 | 0.049431 |
| 10 | 0.021382 | 11.36495 | 86.92950 | 1.102542 | 0.602999 |
| Variance Decomposition of Turkey: | | | | | |
| 2 | 0.038668 | 6.992610 | 0.943770 | 91.96944 | 0.094180 |
| 10 | 0.039369 | 7.780802 | 1.789639 | 90.02660 | 0.402962 |
| Variance Decomposition of Romania: | | | | | |
| 2 | 0.019596 | 0.001400 | 0.029356 | 0.124443 | 99.84480 |
| 10 | 0.019818 | 0.283803 | 1.170268 | 0.403065 | 98.14286 |

Note: Ordering: World Greece Turkey Romania

Table 19 Correlation matrixes of residuals daily returns for a VAR with 15 lags

| | Residual World | Residual Greece | Residual Turkey | Residual Romania |
|---|---|---|---|---|
| Residual World | 1.000000 | 0.224435 | 0.213686 | 0.000833 |
| Residual Greece | 0.224435 | 1.000000 | 0.152917 | 0.024553 |
| Residual Turkey | 0.213686 | 0.152917 | 1.000000 | -0.014398 |
| Residual Romania | 0.000833 | 0.024553 | -0.014398 | 1.000000 |

Table 20 Standard International Capital Asset Pricing Model

$$R_i = \alpha + \beta R_w + e_i \qquad e_i \sim N(0, \sigma^2)$$

where $R_i$ is the excess return on the market *i*, $R_w$ is the global market portfolio return.

| | Greece | Turkey | Romania |
|---|---|---|---|
| $\alpha$ | -0,0002 | -0,0006 | -0,0012 |
| t-stat | -0,4200 | -0,5074 | -2,0819 |
| $\beta$ | 0,5743* | 0,9703* | 0,0039 |
| t-stat | 8,8564 | 6,9449 | 0,0653 |
| AIC | -4,9179 | -3,6721 | -4,9887 |
| SIC | -4,9095 | -3,6637 | -4,9804 |
| Log likelihood | 3011,7540 | 2249,3140 | 3055,1120 |
| Residuals AC (1) | 0,0710* | 0,0130* | 0,2980* |
| Q-Stat | 6,1114 | 0,2048 | 108,8600 |
| Squared residuals AC (1) | 0,1390* | 0,2850* | 0,3520* |
| Q-Stat | 23,6930 | 99,3680 | 151,8400 |
| ARCH Test: (6 lags) | | | |
| F-statistic | 12,3291* | 30,1598* | 32,5688* |
| Obs*R-squared | 70,1190* | 158,3437* | 169,2340* |
| Standardized Residuals | | | |
| Skewness | -0,0341 | -0,0327 | 0,0709 |
| Kurtosis | 4,8785 | 6,8421 | 7,4050 |
| Jarque-Bera | 180,2050* | 753,0490* | 990,6223* |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 21 GARCH (1,1)

$$R_i = \alpha + \beta R_w + e_t \qquad e_t | I_{t-1} \sim N(0, h_t)$$

$$h_t = \omega + \alpha_1 e_{t-1}^2 + \beta_1 h_{t-1}$$

where $R_i$ is the excess return on the market i, $R_w$ is the global market portfolio return, et errors conditional to the information set It-1 follow normal distribution with mean zero and variance $h_t$.

| | Greece | Turkey | Romania |
|---|---|---|---|
| $\alpha$ | -0,0003 | -0,0003 | -0,0007*** |
| | -0,6134 | -0,3677 | -1,7231 |
| $\beta$ | 0,5397* | 0,8602* | -0,0210 |
| | 7,9948 | 6,6730 | -0,4302 |
| $\omega$ | 0,00003* | 0,0002* | 0,0001* |
| | 3,1502 | 3,1144 | 4,8463 |
| $\alpha_1$ | 0,1504* | 0,1669* | 0,5034* |
| | 3,9813 | 3,8464 | 6,4090 |
| $\beta_1$ | 0,7732* | 0,6936* | 0,2385* |
| | 14,9098 | 9,7338 | 2,7870 |
| AIC | -5,0117 | -3,8077 | -5,2216 |
| SIC | -4,9908 | -3,7868 | -5,2007 |
| Log likelihood | 3072,1480 | 2335,2900 | 3200,6060 |
| Squared Residuals AC (1) | -0,0340 | -0,0020 | -0,0030 |
| Q stat | 1,3839 | 0,0032 | 0,0089 |
| ARCH Test: | | | |
| F-statistic | 0,9319 | 0,2784 | 0,3197 |
| Obs*R-squared | 5,5976 | 1,6779 | 1,9263 |
| Standardized Residuals | | | |
| Skewness | -0,1524 | -0,1416 | 0,2566 |
| Kurtosis | 4,8206 | 5,1111 | 5,8890 |
| Jarque-Bera | 173,7884* | 231,3944* | 439,0786* |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 22 GARCH t

$$R_i = \alpha + \beta R_w + e_t$$

$$e_t = \sqrt{h_t} u_t \qquad u_t \sim t(0,1,\nu)$$

$$h_t = \omega + \alpha_1 e_{t-1}^2 + \beta_1 h_{t-1}$$

where $R_i$ is the excess return on the market *i*, $R_w$ is the global market portfolio return, $u_t$ is iid Student – t distributed random variable with mean zero variance one, and ν degree of freedom.

| | Greece | Turkey | Romania |
|---|---|---|---|
| $\alpha$ | -0,0003 | -0,0003 | -0,0012* |
| t-stat | -0,5997 | -0,3868 | -2,9594 |
| $\beta$ | 0,5011* | 0,7360* | -0,0436 |
| t-stat | 9,7912 | 8,1987 | -1,0928 |
| $\omega$ | 0,0000* | 0,0002* | 0,0001* |
| t-stat | 3,2105 | 3,8414 | 5,8235 |
| $\alpha_1$ | 0,1577* | 0,2086* | 0,6337* |
| t-stat | 4,6915 | 4,7480 | 5,3122 |
| $\beta_1$ | 0,7701* | 0,6631* | 0,1807* |
| t-stat | 17,5145 | 11,4615 | 2,9536 |
| ν | 5,8979* | 5,0602* | 3,8806* |
| t-stat | 5,6934 | 6,2907 | 7,0111 |
| AIC | -5,0584 | -3,8718 | -5,3156 |
| SIC | -5,0334 | -3,8467 | -5,2906 |
| Log likelihood | 3099,2260 | 2373,6020 | 3256,5050 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 23 Kolmogorov-Smirnov test that the data are from a specified distribution

| | Statistic | Hypothesis |
|---|---|---|
| Greece GARCH (1,1) | 0,0407 | 1 |
| Greece GARCH (1,1) - t | 0,0120 | 0 |
| Turkey GARCH (1,1) | 0,0458 | 1 |
| Turkey GARCH (1,1) -t | 0,0229 | 0 |
| Romania GARCH (1,1) | 0,0736 | 1 |
| Romania GARCH (1,1) -t | 0,0262 | 0 |

Hypothesis 0 the data are from specified distribution

Hypothesis 1 the data are not from specified distribution

Table 24 EGARCH (1,1)

$$R_i = \alpha + \beta R_w + e_t$$
$$e_t \sim N(0,1)$$
$$\ln h_{it}^2 = \omega + \gamma_1 \left( \left| \frac{e_{t-1}}{\sqrt{h_{t-1}}} \right| - \sqrt{2/\pi} \right) + \alpha_1 \frac{e_{t-1}}{\sqrt{h_{t-1}}} + \beta_1 \ln\left(h_{t-1}^2\right)$$

where $R_i$ is the excess return on the market $i$, $R_w$ is the global market portfolio return, $e_t$ errors conditional to the information set $I_{t-1}$ follow normal distribution with mean zero and variance $h_t$, $\omega$, $\gamma_1$, $\alpha_1$, $\beta_1$ are parameters of variance equation.

| | Greece | Turkey | Romania |
|---|---|---|---|
| $\alpha$ | -0,0009 | -0,0007 | -0,0006 |
| t-stat | -1,6558 | -0,7196 | -1,5175 |
| $\beta$ | 0,5317* | 0,9070* | 0,0247 |
| t-stat | 8,7601 | 6,3809 | 0,5917 |
| $\omega$ | -0,8779* | -0,9607* | -3,7368* |
| t-stat | -3,4265 | -3,0310 | -13,9220 |
| $\gamma_1$ | 0,2728* | 0,2342* | 0,6823* |
| t-stat | 4,7138 | 3,6662 | 16,3012 |
| $\alpha_1$ | -0,0501 | -0,0739*** | -0,0263 |
| t-stat | -1,3282 | -1,8648 | -0,9991 |
| $\beta_1$ | 0,9143* | 0,8815* | 0,5978* |
| t-stat | 31,6279 | 19,4990 | 19,2637 |
| AIC | -5,0195 | -3,8043 | -5,2194 |
| SIC | -4,9945 | -3,7792 | -5,1943 |
| Log likelihood | 3077,9430 | 2334,2170 | 3197,6570 |
| Squared Residuals AC (1) | -0,0380 | 0,0160 | -0,0080 |
| Q-Stat | 1,8071 | 0,3336 | 0,0744 |
| ARCH Test: | | | |
| F-statistic | 1,2170 | 0,4610 | 0,7359 |
| Obs*R-squared | 7,2999 | 2,7758 | 4,4251 |
| Standardized Residuals | | | |
| Skewness | -0,0658 | -0,0682 | 0,3454 |
| Kurtosis | 4,8093 | 5,3477 | 6,0159 |
| Jarque-Bera | 167,8353* | 282,0465* | 487,8319* |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 25 EGARCH (1,1) GED

$$R_i = \alpha + \beta R_w + e_t$$
$$e_t \sim GED(0,1,\nu)$$
$$\ln h_{it}^2 - \zeta_t = \alpha_1 \eta_{t-1} + \beta_1 \left(\ln\left(h_{t-1}^2\right) - \zeta_{t-1}\right)$$
$$\eta_{t-1} = \left(\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \chi_1 \frac{e_{t-1}}{\sqrt{h_{t-1}}},\ \ \zeta_t = \zeta + \ln(1 + \rho N_t)$$

where $R_i$ is the excess return on the market $i$, $R_w$ is the global market portfolio return, $e_t$ errors conditional to the information set $I_{t-1}$ follow generalized error distribution with mean zero and variance $h_t$, and $\nu$, $\zeta_t$, $\zeta$, $\chi_1$, $\rho$, $\alpha_1$, $\beta_1$ are parameters of the equation, $N_t$ number of non-trading days between t and t-1.

| | Greece | Turkey | Romania |
|---|---|---|---|
| $\alpha$ | -0,0006 | -0,0013*** | -0,0005*** |
| t-stat | -1,2675 | -1,5211 | -1,5446 |
| $\beta$ | 0,4959* | 0,6521* | -0,0272 |
| t-stat | 10,0632 | 7,7063 | -0,7683 |
| $\zeta$ | -7,8042* | -6,5772* | -7,8872* |
| t-stat | -64,0075 | -61,8077 | -68,9284 |
| $\rho$ | 0,1847** | 0,1603** | -0,0381 |
| t-stat | 2,4777 | 1,9262 | -0,6444 |
| $\chi_1$ | -0,2181** | -0,3763* | -0,0461 |
| t-stat | -2,4813 | -3,1228 | -0,6431 |
| $\beta_1$ | 0,9129* | 0,8641* | 0,6388* |
| t-stat | 32,5498 | 24,1416 | 11,4364 |
| $\alpha_1$ | 0,2883* | 0,2834* | 0,7223* |
| t-stat | 6,0680 | 5,5176 | 8,9333 |
| $\nu$ | 1,3620* | 1,2129* | 1,0635* |
| t-stat | 18,9640 | 20,1564 | 19,2164 |
| AIC | -5,0673 | -3,8765 | -5,3296 |
| SIC | -5,0339 | -3,8431 | -5,2962 |
| Log likelihood | 3106,6410 | 2378,5080 | 3267,0710 |

Note: * denotes significance at 1%, ** denotes significance at 5%, *** denotes significance at 10%,

Table 26 Kolmogorov-Smirnov test that the data are from a specified distribution

| | Statistic | Hypothesis |
|---|---|---|
| Greece EGARCH (1,1) | 0,0401 | 1 |
| Greece EGARCH (1,1) - GED | 0,0168 | 0 |
| Turkey EGARCH (1,1) | 0,0440 | 1 |
| Turkey EGARCH (1,1) - GED | 0,0196 | 0 |
| Romania EGARCH (1,1) | 0,0746 | 1 |
| Romania EGARCH (1,1) - GED | 0,0352 | 0 |

Hypothesis 0 the data are from specified distribution

Hypothesis 1 the data are not from specified distribution