The Use of Risk and Return for Testing the Stability of Stock Markets

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Abstract: The European Central Bank stipulates that a financial system is stable if the financial risks are evaluated and rewarded correctly and if the economic and financial shocks are absorbed. When analyzing the return and volatility of the stock exchanges we may ascertain that a stock exchange is stable if there is a connection between return and volatility and if the shocks determined by the new positive and negative information do not cause significant changes of the volatility. We took into consideration the values of the indices of stock markets from Holland (AEX), Belgium (BEL), Romania (BET), Hungary (BUX), Germany (DAX), France (CAC), Czech Republic (PX), Slovakia (SAX), Austria (ATX), Estonia (OMXT), Latvia (OMXR) and Lithuania (OMXV). In order to test the relationship between return-volatility and volatility asymmetry we estimated a GJR-GARCH-M model. The results confirm the lack of existence of a correlation between return and volatility for the entire period under analysis and the existence of the volatility asymmetry.

Keywords: conditional volatility; financial crises; heteroscedastic models

JEL Classification: G15; C01; C22

1. Introduction

The financial and economic crises which appeared in the 90s directed the researchers' attention towards a new research topic, namely financial stability. Until now, a unanimously accepted definition financial stability had not been reached for. We can say that there are two thinking trends which try to propose definitions: one trend presents direct definitions through the financial stability (Padoa-Schiopa, 2003), (Foot, 2003) while the second trend indirectly presents definitions by means of financial instability (Davis, 2001), (Ferguson, 2003). At the same time, Issing O. (2003) underlines the presence of two other approaches when defining financial stability: one is based on the approach of a system and the other one is based on the observance of the volatility of financial variables.

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Padoa-Schiopa T. (2003) presents financial stability as being “a condition where the financial system is able to withstand shocks without giving way to cumulative processes, which impair the allocation of savings to investment opportunities and the processing of payments in the economy”.

The conditions that must be met for financial stability according to Foot (2003) are “(a) monetary stability; (b) employment levels close to the economy’s natural rate; (c) confidence in the operation of the generality of the key financial institutions and markets in economy; and (d) where there are no relative price movements of either real of financial assets within the economy that will undetermine (a) or (b)”.

Allend and Wood (2006) presents financial instability as being “episodes in which a large number of parties, whether they are household, companies or (individual) governments, experience financial crises which are not warranted by their previous behaviour and where these crises collectively have seriously adverse macro-economic effects”

According to the European Central Bank the financial system (containing the financial intermediates, the financial markets and the infrastructures of financial markets) is stable if it has the following features: it is capable to transfer efficiently and without problems the resources of those who save for the investors; the financial risks are evaluated and rewarded correctly and they also need to be well managed; they should be able to absorb comfortably surprises and real economic and financial shocks.

The stock market, a component of the capital market, may contribute to the stability of the financial system through all the above-mentioned elements. If we analyze two financial variables, the return and volatility of stock markets, we could test whether the last two characteristics of the financial stability, as they are defined by the European Central Bank and as they are suggested by Padoa-Schiopa’s definition, are met on the stock market. If we analyze the return and volatility of stock markets we can identify whether the last two characteristics are met.

Thus, in our opinion, in order for the financial risks to be correctly evaluated and rewarded on the stock market there should be a correlation between return and risk on one hand and return and conditional volatility on the other hand. The stock market will also absorb the news and the real economic and financial shocks when volatility does not register a significant increase.

Previous studies on the Romanian stock market confirm the choice of EGARCH heteroscedastic model (Lupu & Lupu, 2007) for the return of the BET-C index portfolio analysed during the period 3rd of January 2002 - 17th of November 2005. This model confirms the existence of the asymmetry phenomenon of the impact of new information on the market return which implies that a negative shock of the same intensity as a positive one leads to a higher increase in volatility (asymmetric volatility).

Baur and Schulze (Baur & Schulze, 2009) test the stability of stock markets in Asia in comparison with the developed countries and propose a test based on the results obtained through quantile regression. Ayinde T. O., and Yinusa O. G (Ayinde & Yinusa, 2013) also use the quantile regression to test the stability of stock markets in Africa.

In order to test the necessary still not sufficient conditions for financial stability we will focus on the observance and analysis of return and volatility of stock markets in countries from Central and East Europe as well as in Euro zone countries for comparison purposes. Therefore, we will continue with the presentation of the working methodology and the data used then with the empirical results obtained and we will end with a brief presentation of the results in conclusions.

2. Data and Methodology

In order to analyze the stability of stock markets in the member countries of European Union by means of return, risk and conditional volatility, we took into consideration the indices of the stock markets from Holland (AEX), Belgium (BEL), Romania (BET), Hungary (BUX), Germany (DAX), France (CAC), Czech Republic (PX), Slovakia (SAX), Austria (ATX), Estonia (OMXT), Latvia (OMXR) and Lithuania (OMXV). The values of indices are registered on a daily frequency and the data were taken from the websites of the respective stock markets and from yahoo.finance. The registration period is comprised within the interval 3.01.2000-11.06.2013. For each index there are 3,507 values on the basis of which 3.506 daily log-returns were determined according to the following relation:

$$r_t = log\left(\frac{P_t}{P_{t-1}}\right) * 100$$

A possibility to test the relation between return and volatility for a stock market resides in the estimation of average heteroscedastic models for the returns of general index portfolios of the market. In order to study the possibility to estimate these models we need to test first the dependence of returns. The returns are dependent if their high values are followed by high values as well and the low values are followed by low values regardless of their sign. The returns' dependence is studied by means of the Ljung-Box test applied to the square values of returns.

The stock market absorbs the real economic and financial shocks when the volatility does not register a significant increase under the influence of a shock. If a negative shock of the same size with a positive shock determines a higher volatility then the stock market presents asymmetric volatility. The asymmetry of volatility suggests that shocks are not absorbed but determine a significant increase in volatility. A possible test of volatility asymmetry can be performed by means of the estimation of asymmetric heteroscedastic models. The shocks of the stock demand and offer may determine significant changes on market return and volatility. To see whether there are significant influences of demand and offer on return and volatility according to the days of the week we will work with dummy variables.

As a consequence the hypotheses that we test are:

- the existence of the relationship between risk and volatility on the stock exchange
- the existence of asymmetry of the stock markets' volatility
- the existence of seasonality of return and volatility for the stock exchanges

We will include all the hypotheses previously presented in the following heteroscedastic model:

the mean equation is represented by the corresponding ARMA model to which we added four dummy variables for the days of Tuesday (D2), Wednesday (D3) Thursday D4) and Friday (D5) and the conditional variance. The conditional variance present in the mean equation is specific to the average heteroscedastic models and may indicate the correlation between return and volatility. The dummy variable D2 takes the value 1 when it's Tuesday and zero for the rest, the variable D3 takes the value 1 for Wednesday and zero for the rest etc. Therefore, the comparison of returns will be performed taking into consideration Monday whose average return will be estimated by means of the model constant. The coefficient of the dummy variable D2 will express the difference between the average return obtained on Tuesdays and the average return obtained on Mondays, while the coefficient of the dummy variable D3 will express the difference between the average return obtained on Wednesdays and the average return obtained on Mondays etc (Kim & Lee, 2008).

$$r_t = a_0 + \sum_{i=1}^{p} a_i r_{t-i} + \sum_{j=1}^{q} b_j \varepsilon_{t-j} + \varepsilon_t + \sum_{k=2}^{5} d_k D_k + \nu \sigma_t^2$$

the variance equation is represented by an asymmetric GJR-GARCH model introduced by Glosten et alii (1993) to which we added as dummy variables for the days of Tuesday (D2), Wednesday (D3) Thursday D4) and Friday (D5) as they have been previously defined. The coefficient of the dummy variable D2 will express the difference between the existing volatility on Tuesdays and the existing volatility on Mondays, the coefficient of the dummy variable D3 will express the difference between the existing volatility on Wednesdays and the existing volatility on Mondays etc. Such a model GJR(1,1) presents the following equation of the conditional variance:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 S_{t-1}^- \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \delta_i \sum_{i=2}^{5} D_{it}$$

where: S_{t-1}^{-} represents a dummy variable which takes the value 1 when ε_{t-1} <0 and 0 for the other cases.

2. Empirical Analysis

The evolution of returns and values of the portfolios of stock exchange indices under analysis are presented in figures 1 and 2. The two figures suggest that the returns of index portfolios are stationary in a limited sense, the mean being constant and the variance varying within certain limits. A confirmation of this hypothesis will be obtained by means of the extended Dickey Fuller test

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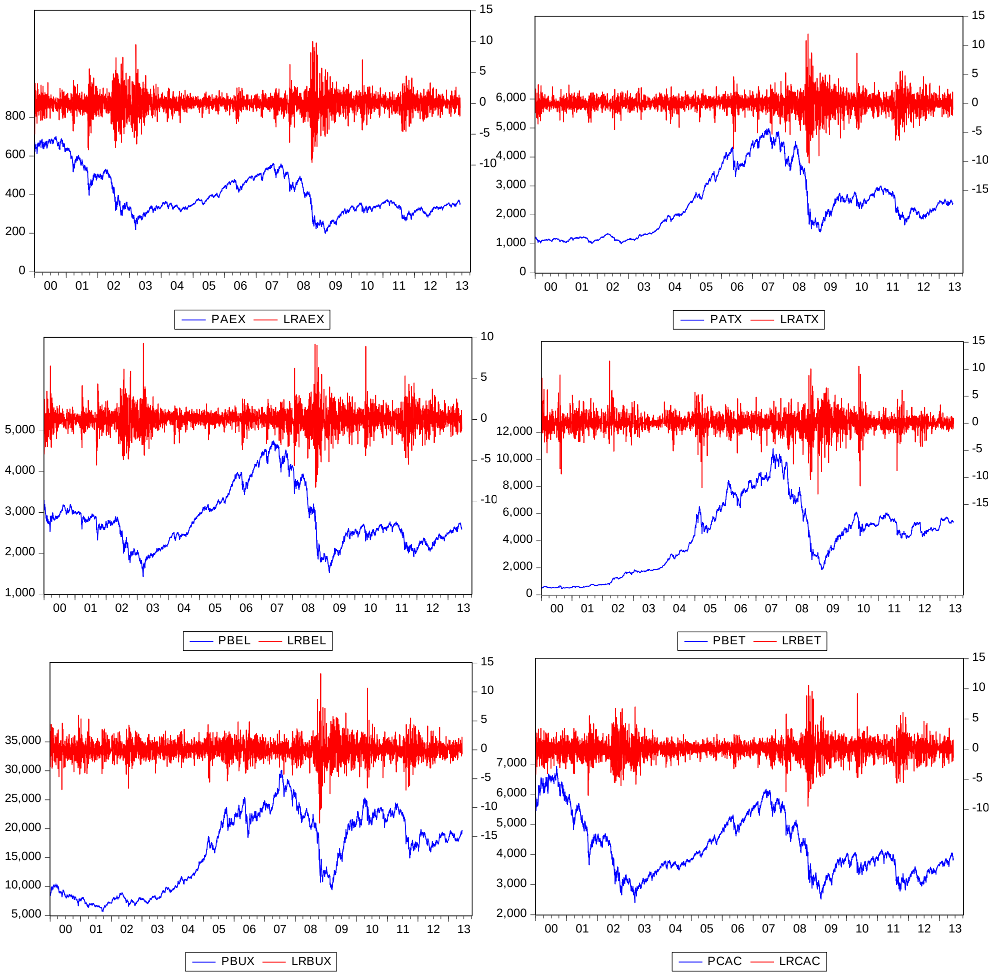

Figure 1. The evolution of returns and values of index portfolios of stock exchanges in Holland, Austria, Belgium, Romania, Hungary and France

From the graphical representations we may ascertain that when the stock exchange has a general descending evolution the volatility of index portfolios analysed is higher than when the stock exchange has a general ascending evolution.

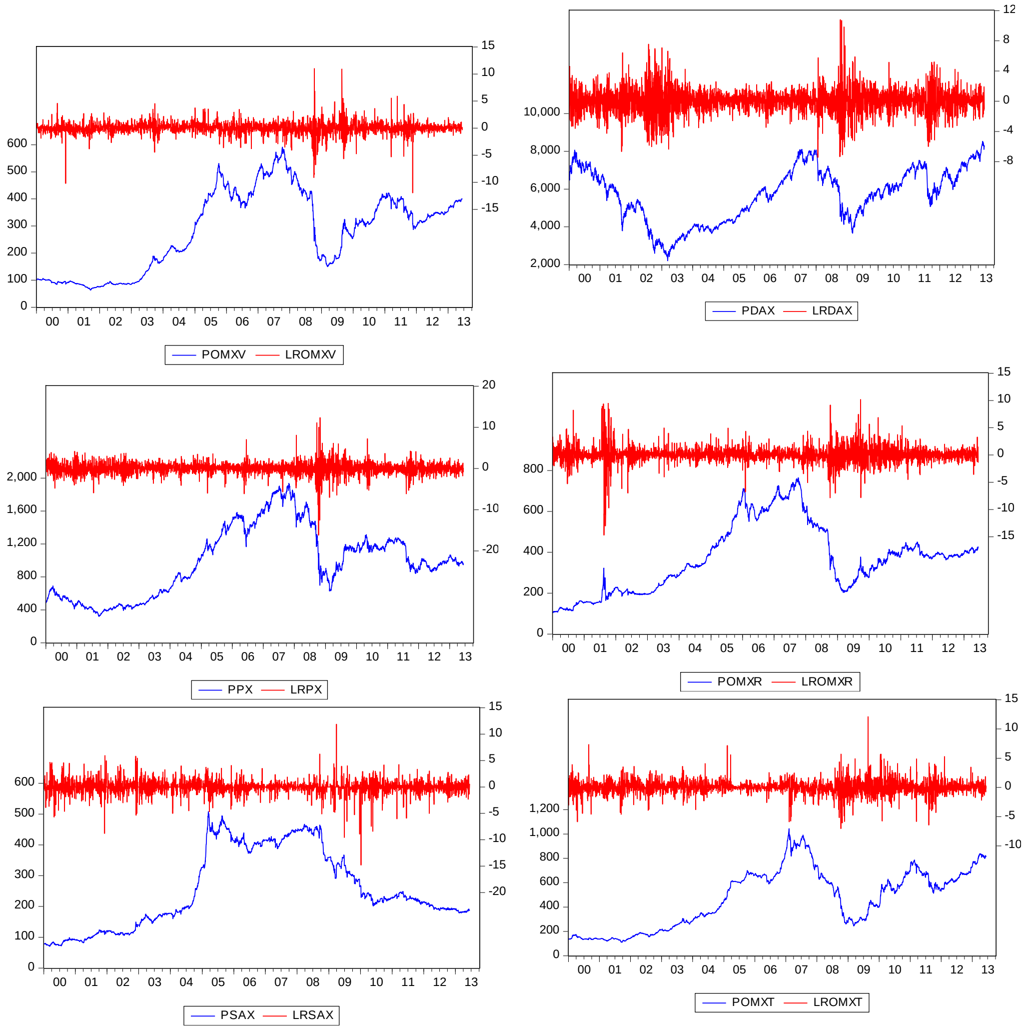

Figure 2. The evolution of returns and values of index portfolios of stock exchanges in Germany, Latvia, Estonia, Lithuania, Czech Republic and Slovakia

The descriptive statistical indicators of the returns of index portfolios show that the highest average return is registered for the Romanian stock exchange. In the event of its stationarity, the investors should expect to obtain profit from one day to another since they own the portfolio. We also notice that the highest return of the stock exchange in Romania is accompanied by the highest risk (measured through the standard deviation) on the stock markets analysed. This also confirms that it is comprised in the emerging markets.

Table 1. The estimation of descriptive statistics for the returns of index portfolios

	LRAEX	LRATX	LRBEL	LRBET	LRBUX	LRCAC	LRDAX	LOMXR	LOMXT	LOMXV	LRPX	LRSAX
Medie	-0.0174	0.0189	-0.0055	0.0665	0.0231	-0.0106	0.0055	0.0395	0.0511	0.0391	0.0181	0.0251
Mediană	0.0000	0.0040	0.0056	0.0163	0.0000	0.0000	0.0369	0.0000	0.0438	0.0095	0.0000	0.0000
Maxim	10.028	12.021	9.3339	11.544	13.177	10.594	10.797	10.179	12.094	11.001	12.364	11.880
Minim	-9.5903	-10.252	-8.3192	-13.116	-12.648	-9.4715	-7.4334	-14.705	-7.0458	-11.937	-16.185	-14.810
Abatere Standard	1.5295	1.4768	1.3196	1.6972	1.6029	1.5379	1.5819	1.4950	1.1750	1.1083	1.4816	1.1849
Asimetrie	-0.0416	-0.3008	0.0637	-0.4157	-0.0730	0.0398	0.0267	-0.6171	0.1327	-0.4963	-0.4627	-0.9232
Boltire	9.3283	10.563	9.0116	10.832	9.0395	7.7314	7.1935	18.364	11.104	21.602	15.203	20.479
Testul Jarque-Bera	5844.6	8401.1	5275.8	9053.4	5325.6	3267.5	2566.4	34667.	9594.0	50636.	21855.	45080.
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000	0.0000

To test the hypotheses we will go through the following stages:

- testing the stationarity of the returns of indices portfolios of analyzed stock exchanges by means of the extended Dickey-Fuller test;
- estimating the functions of total and partial autocorrelation of the returns of the indices portfolios of the analyzed stock exchanges in order to identify the appropriate ARMA model; if the total and partial autocorrelation functions do not offer certain clues we will estimate ARMA models with different parameters and based on the Akaike and Schwarz criteria we will choose the best ARMA model;
- testing the dependence of the returns in order to identify the possibility of modelling by means of heteroscedastic models;
- estimating the proposed GJR-GARCH-M model in order to test the existence of the correlation between risk, volatility, volatility asymmetry and seasonality of return and risk.

The estimated parameters of heteroscedastic GJR-GARCH-M for the returns of index portfolios AEX, ATX, BEL, BET, BUX and CAC presented in the table above show that there is not a correlation, during the period analyzed, between return and volatility. For the Romanian stock exchange the result confirms the previous studies (Chirilă V., Chirilă, C., 2012). Still, the correlation between return and volatility was confirmed in the previous studies by the growth periods of the stock exchange and invalidated during the downturn periods of the stock exchange.

That is why it is necessary to continue the analysis by stages of the stock exchange business cycles.

The returns of these stock exchanges do not present seasonality. The exception is made by the Bucharest Stock Exchange whose return on the days of Thursday and Friday is higher and differs significantly from the Mondays' return.

The estimated equations of the variances presented in table 2 confirm the existence of the volatility asymmetry at the stock exchanges in Holland, Austria, Belgium, Romania, Hungary and France. Therefore, the shocks or the new negative information occurring at the stock exchange determine a higher volatility in comparison with the positive shocks.

Table 2. The estimation of heteroscedastic models GJR-GARCH-M for the returns of index portfolios AEX, ATX, BEL, BET, BUX and CAC

	LRAEX	LRATX	LRBEL	LRBET	LRBUX	LRCAC
Mean equation						
a_0	0.002594 *(0.8119)*	-0.015946 *(0.2822)*	-0.014314 *(0.3349)*	0.002349 *(0.8821)*	-0.001488 *(0.9334)*	0.006256 *(0.6041)*
ν	0.018296 *(0.5896)*	0.051350 *(0.1990)*	0.022960 *(0.4668)*	0.002019 *(0.9728)*	0.064926 *(0.2326)*	-0.029480 *(0.4810)*
d_2	-0.042676 *(0.4034)*	0.013114 *(0.7969)*	-0.001623 *(0.9705)*	0.105460 *(0.0867)*	-0.054508 *(0.4100)*	-0.011344 *(0.8508)*
d_3	-0.064852 *(0.1682)*	0.044657 *(0.3911)*	0.054147 *(0.2035)*	0.086947 *(0.2015)*	-0.090327 *(0.1989)*	-0.001667 *(0.9759)*
d_4	-0.027721 *(0.5646)*	0.002425 *(0.9622)*	-0.002633 *(0.9517)*	0.135544 ***(0.0386)***	-0.026421 *(0.6968)*	0.031642 *(0.5748)*
d_5	0.018344 *(0.7012)*	0.045806 *(0.3457)*	0.021191 *(0.6134)*	0.139663 ***(0.0279)***	0.005750 *(0.9327)*	0.071069 *(0.2228)*
Variance equation						
α_0	0.080130 *(0.0902)*	0.045338 *(0.3454)*	-0.045555 *(0.1697)*	0.561517 *(0.0000)*	0.081607 *(0.3729)*	0.102619 *(0.0752)*
α_1	0.020080 *(0.0026)*	0.019622 *(0.0302)*	0.014177 *(0.0592)*	0.147751 *(0.0000)*	0.042461 *(0.0000)*	0.020303 *(0.0008)*
γ_1	0.166338 ***(0.0000)***	0.121567 ***(0.0000)***	0.164500 ***(0.0000)***	0.042169 ***(0.0012)***	0.069651 ***(0.0000)***	0.165241 ***(0.0000)***
β_1	0.926352 *(0.0000)*	0.901269 *(0.0000)*	0.890808 *(0.0000)*	0.803440 *(0.0000)*	0.898664 *(0.0000)*	0.924874 *(0.0000)*
δ_2	0.212968 ***(0.0059)***	-0.046083 *(0.5764)*	0.160683 ***(0.0036)***	-0.751853 ***(0.0000)***	0.192887 *(0.2408)*	0.202784 ***(0.0206)***
δ_3	0.069189 *(0.3177)*	0.006511 *(0.9224)*	0.027113 *(0.5801)*	-0.486713 ***(0.0000)***	0.347168 ***(0.0081)***	0.098140 *(0.2390)*
δ_4	0.172179 ***(0.0167)***	0.022923 *(0.7431)*	0.128894 ***(0.0173)***	-0.510234 ***(0.0000)***	-0.082272 *(0.5443)*	0.177961 ***(0.0496)***
δ_5	0.029914 *(0.7388)*	-0.072438 *(0.3905)*	0.007721 *(0.9042)*	-0.583142 ***(0.0000)***	0.226163 *(0.1365)*	0.149289 *(0.1880)*

Note: *Between brackets we presented the probabilities associated to the t test for the test of the significance of estimated coefficients*

The results presented in table 2 confirm the existence of seasonality for Holland, Romania, Hungary and France. Holland and France have significantly higher volatilities on Tuesdays and Thursdays unlike on Mondays, Hungary has significantly higher volatilities on Wednesdays while Romania has stock exchange volatilities significantly lower on all days excepting the Mondays.

Table 3. The estimation of heteroscedastic models GJR-GARCH-M for the returns of index portfolios DAX, OMXR, OMXT, OMXV, OMXPX, SAX

	LRDAX	LROMXR	LROMXT	LROMXV	LRPX	LRSAX
Mean equation						
a_0	0.009451	-0.035472	0.002512	0.042872	-0.013273	0.038629
	(0.4224)	***(0.0067)***	*(0.9164)*	*(0.1780)*	*(0.4527)*	*(0.1808)*
ν	0.006561	-0.024352	-0.004155	-0.073807	0.073306	-0.055566
	(0.8808)	*(0.5492)*	*(0.9150)*	*(0.1729)*	*(0.1093)*	*(0.3407)*
d_2	-0.026886	0.130805	0.047514	0.080257	-0.059777	-0.034495
	(0.6583)	***(0.0103)***	*(0.1917)*	*(0.0647)*	*(0.2901)*	*(0.5725)*
d_3	-0.029697	0.117634	0.070764	0.157672	0.018816	0.041905
	(0.6150)	***(0.0174)***	*(0.0968)*	***(0.0002)***	*(0.7437)*	*(0.4567)*
d_4	0.015030	0.177001	0.056603	0.122526	0.012928	0.065271
	(0.7941)	***(0.0005)***	*(0.1804)*	***(0.0076)***	*(0.8268)*	*(0.2631)*
d_5	0.026436	0.223127	0.110136	0.166836	0.005280	0.025775
	(0.6471)	***(0.0001)***	***(0.0058)***	***(0.0000)***	*(0.9197)*	*(0.6524)*
Variance equation						
α_0	0.043367	0.008090	0.069456	0.303332	0.111784	0.102368
	(0.4882)	*(0.8220)*	*(0.0133)*	*(0.0000)*	*(0.0652)*	*(0.0052)*
α_1	0.017911	0.111163	0.123297	0.106000	0.065572	0.045578
	(0.0122)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*
γ_1	0.161705	0.026687	0.003717	0.100222	0.097947	0.004395
	(0.0000)	***(0.0077)***	*(0.6835)*	***(0.0000)***	***(0.0000)***	***(0.1660)***
β_1	0.921369	0.858011	0.878788	0.777209	0.855763	0.934130
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*	*(0.0000)*
δ_2	0.128307	-0.179619	-0.124406	-0.335424	0.017715	0.030769
	(0.1899)	***(0.0053)***	***(0.0178)***	***(0.0000)***	*(0.8678)*	*(0.6093)*
δ_3	0.118740	0.235402	-0.057856	-0.290088	-0.060504	-0.472313
	(0.1705)	***(0.0000)***	*(0.1130)*	***(0.0000)***	*(0.4782)*	***(0.0000)***
δ_4	0.016313	0.094469	-0.061124	-0.088930	0.029293	0.131477
	(0.8583)	*(0.0708)*	*(0.1034)*	***(0.0017)***	*(0.7344)*	***(0.0056)***
δ_5	0.088459	0.097409	-0.030926	-0.393120	-0.270541	-0.054181
	(0.4545)	*(0.0669)*	*(0.4407)*	***(0.0000)***	***(0.0073)***	*(0.3761)*

Note: Between brackets we presented the probabilities associated to the t test for the testing of the significance of estimated coefficients

The estimated parameters of the heteroscedastic models GJR-GARCH-M for the returns of index portfolios DAX, OMXT, OMXV, OMXPX, SAX presented in the table above highlight that there is not a correlation, during the analyzed period, between return and volatility. The exception is represented by the OMXR index portfolio which confirms the existence of the correlation between return and volatility at the stock exchange from Lithuania.

The returns of the index portfolios DAX, PX and SAX do not present seasonality. At the stock exchange from Latvia the return on Tuesdays, Wednesdays, Thursdays and Fridays is significantly higher than the return on Mondays. In Estonia (OMXT) the stock exchange return is significantly higher on Fridays and in Lithuania the stock exchange return on Wednesdays, Thursdays and Fridays is significantly higher than on Mondays.

The volatilities of the returns of index portfolios DAX, OMXT, OMXV, OMXPX, SAX are characterised by asymmetry, with the exception of OMXR. Therefore, the new negative information on the stock exchanges from Germany, Estonia, Lithuania, Czech Republic and Slovakia determine a higher volatility than the new positive information of the same magnitude.

3. Conclusion

Testing the stability of stock markets is very important for forecasting the financial stability in general since the evolution of stock markets is considered to anticipate economic and financial shocks. In this paper we aimed to test a necessary but not sufficient condition for the stability of financial markets as it is defined by the European Central Bank, by taking into consideration volatility and return. The analysis is conducted by means of an estimated heteroscedastic model, GJR-GARCH-M, which can highlight the existence of volatility asymmetry, the correlation between return and volatility and perhaps the seasonality of return and volatility. The results obtained confirm that the stock markets analyzed do not meet the necessary conditions for stability.

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