DOES VOLATILITY RESPOND ASYMMETRIC TO PAST SHOCKS?

Claudiu Boţoc[1]

ABSTRACT: The main aim of the paper is to examine if the stock market volatility exhibits a symmetric or an asymmetric response to past shocks, for certain CEE countries (Romania, Hungary, Bulgaria, Poland) over the period May 2004 – September 2014. For the stock markets from East Europe the results are in line with the symmetric volatility, i.e. volatility is similar affected by both positive and negative returns with the same magnitude. For the stock markets from Central Europe the results are consistent with the leverage hypothesis of the asymmetric volatility, i.e. negative and positive returns with the same magnitude have different impact on volatility. Furthermore the volatility is more sensitive to its lagged values in the market place than it is to new information. These results reinforce the diversification principle that has to be considered in portfolio and risk management process.

Keywords: volatility, leverage effect, feedback hypothesis, CEE countries, GARCH

JEL Codes: G11, G14

1. Introduction

Understanding and modeling volatility represent a key issue in financial markets due to the several implications in risk management process, portfolio management, hedging and pricing operations or economic policy. It is well known that a capital markets high volatility is an unstable one and motivate the investors to require a higher risk premium.

Loosely speaking, volatility is a consequence of trading which describe three dependent and interactive concepts, fundamentals, information and market expectations respectively. It is worth to be noticed that the aforementioned concepts generate a chain reaction for issuers and investors which will determine a post information equilibrium price. For instance, changes in corporate policy and performance (business strategy, quality of the products, profitability) will be followed by variations in stock prices, i.e. an increased volatility. At the same time, changes in corporate fundamental and environmental information will determine the participants to review their expectations which again cause price variations and implicitly stock market volatility.

As a simple risk measure determined by standard deviation, stock market volatility is a useful indicator for several stakeholders belonging to financial markets. First and foremost, it is important for investors interested in making rational decisions and profitable investments. Second, is important for traders interested in determining the predictability of stock prices. Third, is important for the policymakers since it provide them a useful tool to foresee financial crisis.

The main aim of the paper is to examine the stock market volatility for certain Central and East European countries (Romania, Hungary, Bulgaria, Poland) in the period May 2004-September 2014. Particularly, it is of importance if the volatility exhibits a symmetric or an asymmetric response to past shocks, if reacts different to negative and positive shocks. The motivation for the topic is related to the conflicting results from the previous findings for CEE countries which lead the conclusion that additional research is required in order to reach a consensus. In this respect, the

[1] Lecturer PhD, West University of Timişoara, Faculty of Economics and Business Administration, Finance Department, e-mail: claudiu.botoc@e-uvt.ro

paper contributes to the literature due to the recent period examined (up to September 2014) which has not been covered in previous studies of CEE stock markets.

Using both classical models (GARCH-M) and flexible models (TARCH-M and EGACRH-M) the results are appealing. First, leverage hypothesis of the asymmetric volatility was not rejected for Central countries (Hungary, Poland). Second, the asymmetric volatility hypotheses, either leverage or feedback, were rejected for Eastern countries (Romania, Bulgaria). In other words, during the period tested, for Eastern countries positive and negative returns of the same magnitude have similar impacts on the volatility level, which is not the behavior for Central countries. These results reinforce the diversification principle that has to be considered in financial market investments.

The rest of the paper is structured as follows. In the next section is briefly discussed the literature on the stock market volatility, with an emphasis on the theories of asymmetric volatility. Section 3 explains the data and the empirical methodology. In Section 4 are discussed the main results and Section 5 concludes.

2. Literature review

There are two main hypothesis developed within asymmetric volatility, leverage effect and volatility feedback respectively. The leverage effect hypothesis states that if stock price decrease debt ratio will increase and thus volatility of stock return for shareholders is increased (Black 1976; Christie, 1982). The volatility feedback hypothesis states that an increase in volatility is associated with both an increase in risk and an increase in the expected future risk (Pindyck, 1984; Campbell and Hentschel, 1992). Since asymmetries in other instruments cannot be associated to changing leverage, it is difficult to assume that such asymmetries exist only in equity returns.

Recently, additional hypotheses were provided for the asymmetric behavior. On the one hand, an asymmetric volatility hypothesis in aggregate market returns have been developed, which based on the relation between market return and firm return (Bekaert and Wu, 2000). On the other hand, asymmetric volatility is explained by selling activity, level of information owned by investors and the return (Avramov et al., 2006).

In dynamic investigation of financial time series it is of great importance to consider the conditional mean and the heteroskedasticity. The autoregressive conditional heteroskedasticity (ARCH) models were developed to deal with this econometric issue, first by Engel (1982) and generalized by Bollerslev (1986) and Taylor (1986).

Early time-series models, such as ARCH and GARCH, incorporated the assumption that volatility has a symmetric response to positive and negative shocks, based on the idea that volatile markets tend to follow volatile markets. Due to its weakness, several extensions emerged, such as TARCH/EGARCH/PGARCH/IGARCH flexible models, which assume that stock volatility has an asymmetric response in that negative shocks have a greater impact than positive shocks (Poon and Granger, 2003).

There is a consistent body of empirical analysis that has focused on both developed and emerging stock markets. When looking to the CEE countries, both symmetric (Murinde and Poshakwale, 2002; Miron and Tudor, 2010) and asymmetric volatility (Patev and Kanaryan, 2006; Harrison and Moore, 2011) behavior was found. Furthermore, the asymmetric volatility was supported through leverage effect hypothesis (Bollerslev et al., 2006). Surprisingly or not, for the same countries (Poland, Hungary, Romania) it were found contradictive results (symmetric and asymmetric volatility) when different period were examined

Also it was found that emerging stock markets from CEE countries exhibit higher volatility than developed stock market. A possible explanation is related to the youngness level of market capitalization, volume and companies listed, which trigger a higher growth rate.

3. Data and methodology

The data consists of daily observations of stock market indices for several Central and East European Countries (formerly known as CEECs) from the period 03.05.2004 to 19.09.2014 (541 weeks). Based on a representatively criteria, in terms of average index price, the CEECs analyzed are Romania (Index Name: BET), Hungary (Index Name: BUX), Bulgaria (Index Name: SOFIX) and Poland (Index Name: WIG 20). The starting period is related to the EU accession of Hungary and Poland, when such countries have to adjust their legislative and regulatory capital market framework. The daily prices were obtained from Datastream International and daily return is computed as continuous compounding return using the following formula:

$$R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

where R_t is the index return and P_t and P_{t-1} reflect closing price index at times t and t-1 respectively.

In order to model the volatility, the Generalized Autoregressive Heteroskedasticity (GARCH) econometric procedure is employed (Engle, 1982), which deal with distributional characteristics of return (Brooks, 2008). Based on previous findings (Guidi et al., 2011; Murinde and Poshakwale, 2002), in the first step a GARCH-M (1,1) model with the following specification is estimated:

$$R_t = \mu + \delta \times \sigma_{t-1} + u_t,\ u_t \approx N\left(0, \sigma_t^2\right) \tag{2}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2 \tag{3}$$

Second, particular diagnostic and misspecification tests will be carried out in order to fit the model. Later, an asymmetric test is performed for modeling asymmetric volatility. The main efficient extensions for modeling asymmetric volatility are (i) TARCH-M(1,1) having the following specification:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \beta \times \sigma_{t-1}^2 + \gamma \times u_{t-1}^2 \times I_{t-1}$$

where $\qquad (4)$

$$I_{t-1}\begin{cases} = 1 \text{ if } u_{t-1} < 0 \\ = 0 \text{ otherwise} \end{cases}$$

and (ii) EGARCH-M (1,1) having the following specification:

$$\ln\left(\sigma_t^2\right) = \omega + \beta \times \ln\left(u_{t-1}^2\right) + \gamma \times \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \times \left[\frac{\left|u_{t-1}\right|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] \tag{5}$$

A useful tool in the empirical analysis is the reporting of descriptive statistics and plot in order to assess the distributional characteristics and stochastic properties of the data. The descriptive statistics are reported in table no. 1 and suggest that the index return for all stock markets have a leptokurtotic distribution, i.e. negative skewness and excess kurtosis. Such unconditional non-normal distribution is confirmed too by the Jarque-Bera Statistics. Furthermore, the Breusch-Godfrey test (4 lags) rejects the null hypothesis of no serial correlation, while the ARCH LM test suggests the presence of ARCH effects in the residuals. This motivate the estimation of conditional variance using a GARCH-M (1,1) model.

Table no. 1 Descriptive statistics

	Romania	**Hungary**	**Bulgaria**	**Poland**
Mean	0.000295	0.000173	4.72E-05	-5.46E-05

Median	0.000625	0.000425	0.000369	0.000310
Maximum	0.128	0.131	0.072	0.095
Minimum	-0.224	-0.126	-0.138	-0.084
Std. Dev.	0.017	0.016	0.013	0.015
Skewness	-1.319	-0.147	-1.229	-0.140
Kurtosis	21.330	9.697	15.928	6.961
Jarque-Bera	33067.67***	4333.031***	16697.83***	1520.624***
BG Test (4)	8.612***	10.310***	23.136***	3.743***
ARCHLM (4)	33.492***	109.158***	128.427***	58.375***
Observations	2490	2601	2449	2510

BG is Breusch-Godfrey test for serial correlation with 4 lags. ARCH is the Lagrange multiplier test for autoregressive conditional heteroskedasticity with 4 lags.
***,**,* The rejection of the null hypotheses of no autocorrelation, normality and homoscedasticity at the 1%, 5% and 10% respectively levels of significance for statistical tests.
Source: Author calculations using Eviews 7.

Although from table no. 1 one can notice that all indexes exhibit volatility (standard deviation is higher than its mean), this phenomenon is explored in depth by plotting the daily return (Annex, figure no. 1). It is noteworthy that the stock markets analyzed experience periods of turbulence, particularly in 2008, as well as tranquility. These suggest that large price variations tend to follow large variations and small price variations tend to follow small variations, formerly known as volatility clustering.

4. Results

The results of the GARCH-M (1,1) specifications with the normal distribution function and conditional standard deviation term in the mean are reported in Panel A of table no. 2.

Table no. 2 Symmetric volatility models

Parameters	**Romania**	**Hungary**	**Bulgaria**	**Poland**
Panel A GARCH-M(1,1)				
μ	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
δ	0.022	0.026	-0.045	-0.015
	(0.054)	(0.066)	(0.054)	(0.069)
α_0	6.08E-06***	5.03E-06***	4.37E-06***	1.74E-06***
	(7.80E-07)	(9.33E-07)	(5.65E-07)	(4.50E-07)
α_1	0.224***	0.098***	0.248***	0.064***
	(0.012)	(0.009)	(0.016)	(0.006)
β	0.778***	0.881***	0.749***	0.928***
	(0.010)	(0.011)	(0.012)	(0.006)
Panel B GARCH-M(1,1) QML				
μ	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
δ	0.022	0.026	-0.045	-0.015
	(0.044)	(0.071)	(0.043)	(0.064)
α_0	6.08E-06***	5.03E-06***	4.37E-06***	1.74E-06**
	(1.53E-06)	(1.51E-06)	(8.29E-07)	(7.65E-07)
α_1	0.224***	0.098***	0.248***	0.064***
	(0.034)	(0.016)	(0.027)	(0.011)
β	0.778***	0.881***	0.749***	0.928***
	(0.025)	(0.017)	(0.022)	(0.012)
SSB Test	140.337***	234.649***	0.000	46.978***

Standard errors (Panel A) respectively robust standard errors (Panel B) in parentheses.
SSB represent sign and size bias test for asymmetries in volatility.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Source: Author calculations using Eviews 7.

Regarding the risk premium, the estimated parameter of the mean (δ) is insignificant for all stock markets suggesting that there is no feedback from the conditional variance to the conditional mean. On the other hand, ARCH (α_1) and GARCH (β) coefficients are statistically significant and the sum of these coefficients (closer to unity) indicates that shocks to volatility have a persistent effect on the conditional variance. On the other hand, the estimated GARCH coefficients in the conditional variance equation are considerably larger than ARCH coefficients. The implication is that volatility is more sensitive to its lagged values in the market place than it is to new information. According to the GARCH coefficient and consistent with results from figure no. 1 from the Annex, Poland stock market followed by Hungarian stock market are experiencing higher volatility, in comparison with Romania and Bulgaria.

The conditional normality assumption through a misspecification test is then examined. The results are reported in the figure no.2 from the Annex. For all cases, the assumption is rejected, i.e. standardized residuals are non-normally distributed. In order to deal with the inconsistency of the standard error the model was re-estimated by using Quasi Maximum Likelihood (QML) procedure. The results are reported in panel B of table no. 2 and one can observe that robust standard errors and their p-values are different than previous models. However, regarding ARCH, GARCH and risk premium the results remain unchanged.

Another misspecification test that needs to be performed is related to the hypothesis of the independence of standardized residuals. The plot of standardized residuals (figure no. 3 from Annex) and the correlogram squared residuals (table no. 4 from Annex) do not reject the aforementioned hypothesis, linearly and non-linearly respectively.

Therefore, one can conclude that the GARCH-M (1,1) model with robust standard errors is correct specified. In econometrics context GARCH-M models have a major constraint because impose a symmetric response of volatility to both positive and negative shocks. In the financial world it is well known that for the same magnitude of the shocks volatility is asymmetric, respectively it may raise more for the bad shocks than for the good shocks. In this respect, a general test for an asymmetric response (formerly known as SSB) is performed, the results being reported in Panel B of table no. 2. Except Bulgaria, the F-statistic and p-value strongly reject the null of no sign and size bias, and, therefore, GARCH-M(1,1) have to be extended. This lead to a first main finding, that Bulgarian stock market volatility does not respond asymmetric to positive and negative shocks[2].

The results for TARCH-M (1,1) model are reported in Panel A of table no.3 while the results for EGARCH-M (1,1) model are reported in Panel B of table no. 3.

Table no. 3 Asymmetric volatility models

Parameters	**Romania**	**Hungary**	**Bulgaria**	**Poland**
Panel A TARCH-M(1,1)				
μ	0.000	0.000		0.000
	(0.000)	(0.000)		(0.000)
δ	0.012	-0.000		-0.018
	(0.045)	(0.070)		(0.066)

[2] The asymmetric TARCH-M (1,1) and EGARCH-M (1,1) models were estimated for Bulgaria too but collapse. They are made available upon request.

Parameters	**Romania**	**Hungary**	**Bulgaria**	**Poland**
α_0	6.26E-06***	5.67E-06***		2.18E-06***
	(1.53E-06)	(1.53E-06)		(7.88E-07)
α_1	0.210***	0.053***		0.033***
	(0.046)	(0.018)		(0.012)
β	0.778***	0.881***		0.929***
	(0.025)	(0.017)		(0.011)
γ	0.026	0.083***		0.053***
	(0.052)	(0.027)		(0.018)
AIC	-5.764	-5.674		-5.756
BIC	-5.750	-5.661		-5.742
LL	7182.676	7386.109		7230.771
Panel B EGARCH-M(1,1)				
μ	0.000	0.000		0.000
	(0.000)	(0.000)		(0.000)
δ	0.003	0.001		-0.018
	(0.050)	(0.071)		(0.066)
ω	-0.528***	-0.338***		-0.214***
	(0.091)	(0.065)		(0.047)
β	0.348***	0.188***		0.142***
	(0.041)	(0.028)		(0.022)
γ	-0.023	-0.052***		-0.048***
	(0.025)	(0.018)		(0.014)
α	0.968***	0.977***		0.987***
	(0.009)	(0.006)		(0.004)
AIC	-5.761	-5.668		-5.759
BIC	-5.747	-5.654		-5.745
LL	7179.290	7377.348		7233.572

Robust standard errors in parentheses.
AIC, BIC and LL represent Akaike criterion, Schwarz criterion and Log likelihood ratio respectively.
*** p<0.01, ** p<0.05, * p<0.1
Source: Author calculations using Eviews 7.

According to these results one can state that the asymmetry parameter (γ) is significant for Hungarian and Poland stock markets and insignificant for Romanian stock market. Two main findings could be drawn up. First, for Romanian stock market, both TARCH-M (1,1) and EGACRH-M (1,1) models collapse and thus volatility is symmetric. A possible explanation for this symmetric behavior is related to the structure of the investors from Romanian stock market, whereas is well known that is dominated by institutional investors represented by well qualified managers. Second, for Hungarian and Poland stock markets the results support the leverage hypothesis of the asymmetric volatility. Such asymmetry is typically in financial time series and shareholders perceive their future cash flows as being relatively more volatile. In terms of significance, for Hungarian stock market TARCH-M (1,1) model is preferred while for Poland stock market EGARCH-M (1,1) model is preferred.

To sum up, the results are appealing and highlight the importance of replicating previous studies. First, like Patev and Kanaryan (2006), it was found support for leverage hypothesis for the case of Central stock markets, i.e. Hungary and Poland. Second, the results stand in contrast with previous findings for the same markets (Murinde and Poshakwale, 2002). Third, unlike Miron and Tudor (2010) it was found that Romanian stock market do not exhibit asymmetric volatility. The conflicting results for the same countries could be explained, among other, by various methodologies, samples tested or by efficient market behavior. These findings suggest the diversification principle in portfolio and risk management process.

5. Conclusions

The main aim of the paper is to examine the stock market volatility for certain CEE for the period May 2004-September 2014. Nevertheless, it is of importance if the volatility exhibits a symmetric or an asymmetric response to past shocks, if react different to negative and positive shocks.

Using both classical models (GARCH-M) and flexible models (TARCH-M and EGACRH-M) the results are appealing. For Central countries (Hungary, Poland) it was found support for the leverage hypothesis of the asymmetric volatility. Such asymmetry is typically in financial time series and shareholders perceive their future cash flows as being relatively more volatile. For Eastern countries (Romania, Bulgaria) we found support for symmetric volatility, meaning that good and bad news of the same magnitude have similar impacts on the volatility level. On the other hand, the estimated GARCH coefficients in the conditional variance equation are considerably larger than ARCH coefficients. The implication is that volatility is more sensitive to its lagged values in the market place than it is to new information.

The different behavior between Central and Eastern stock markets lies in the size of such markets as well as the structure of the investors from the market. It is well known that small markets such Romanian and Bulgarian are dominated by institutional well qualified investors and therefore there is no different impact between good and bad news. This different impact it is triggered by individual investors and is likely to be encountered in large stock markets, i.e. Poland and Hungarian. These results have implications for foreign investors with different risk profile, interested in several foreign stock markets. For instance, risk-adverse investors would be interested in investing in stock markets with symmetric and low volatility whereas risk lover investors would be interested in investing in stock markets with asymmetric and higher volatility. Finally, the results reinforce the diversification principle that has to be considered in portfolio and risk management process.

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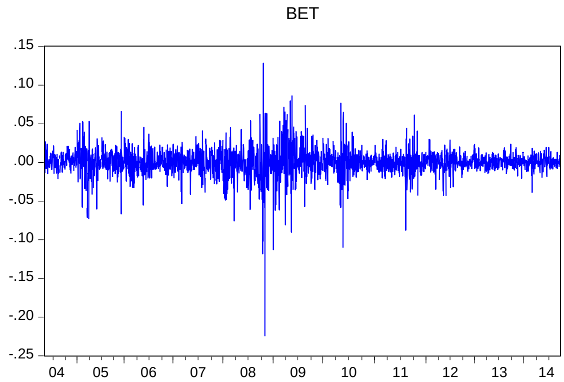
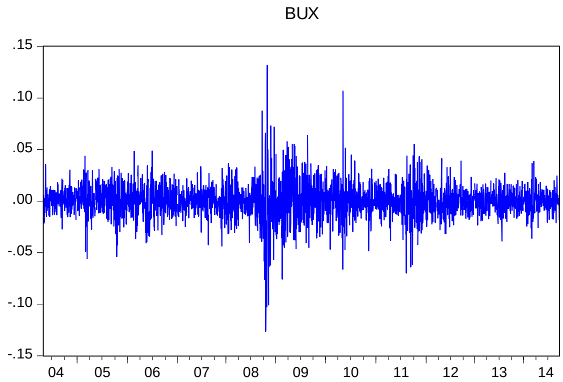
ANNEXES



Romania



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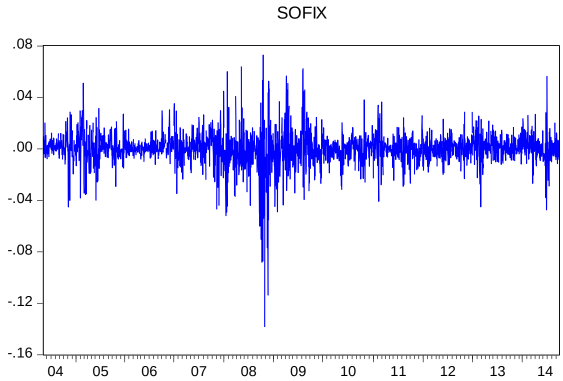
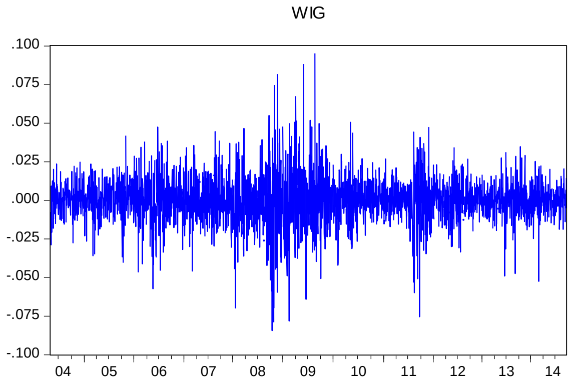
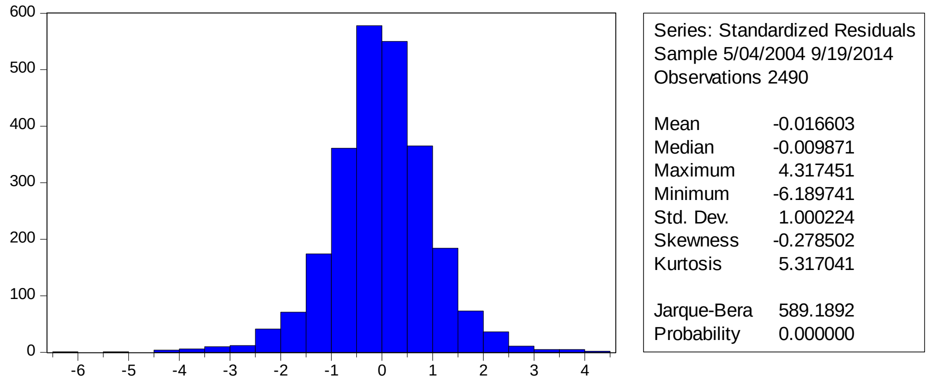


Bulgaria

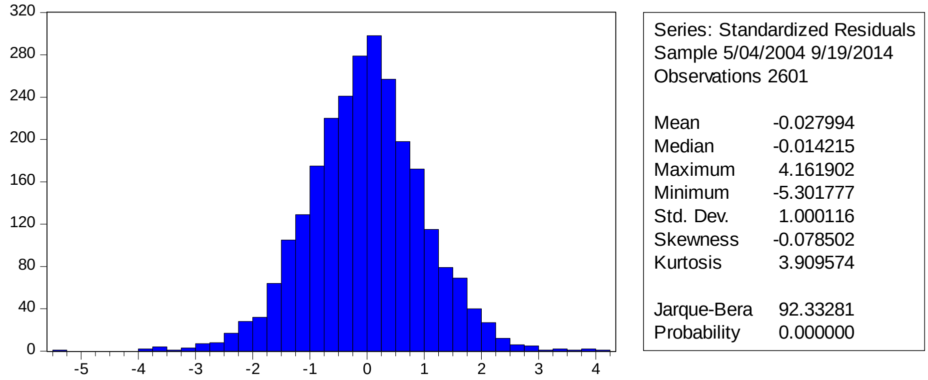


Poland

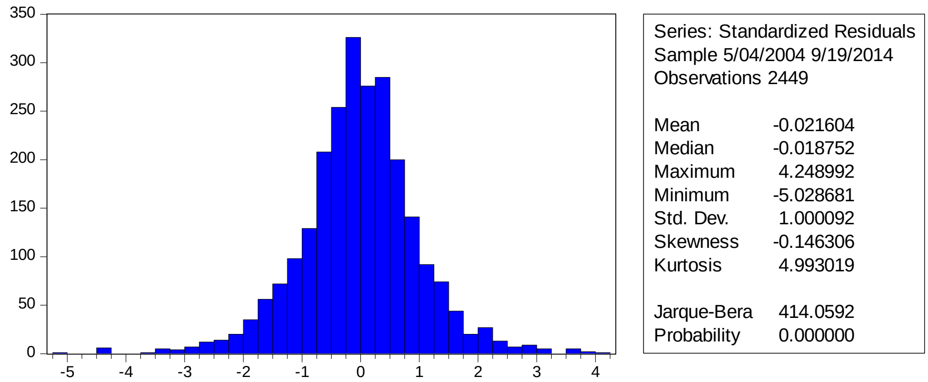
Figure no. 1 Daily plot return



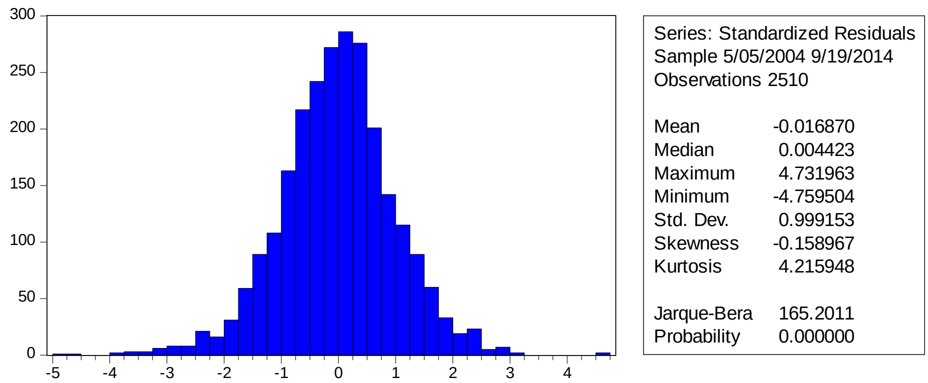
Romania



Hungary

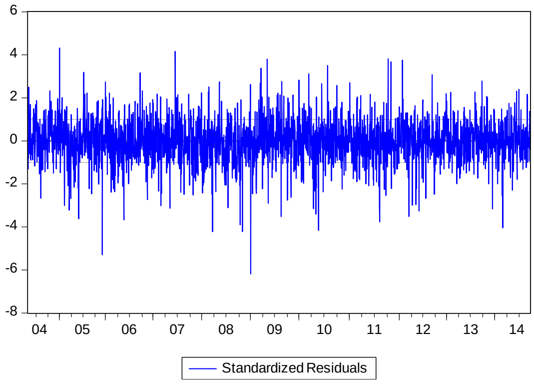


Bulgaria

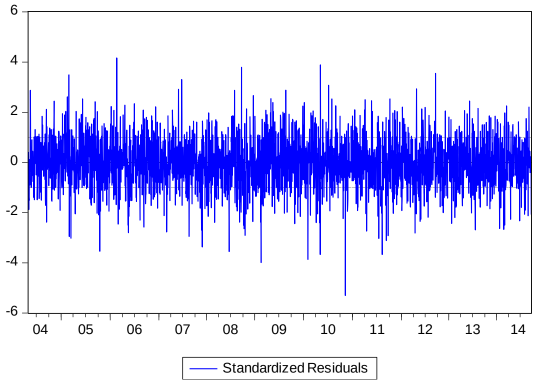


Poland

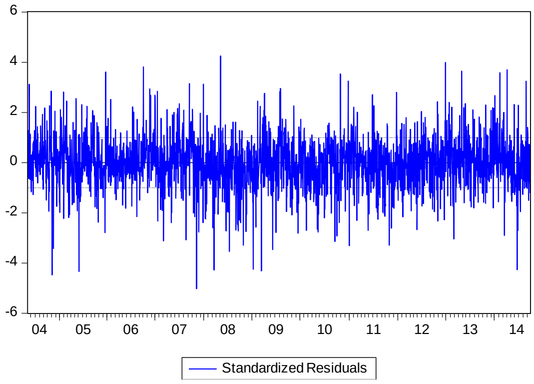
Figure no. 2 Histogram Normality Test Graph



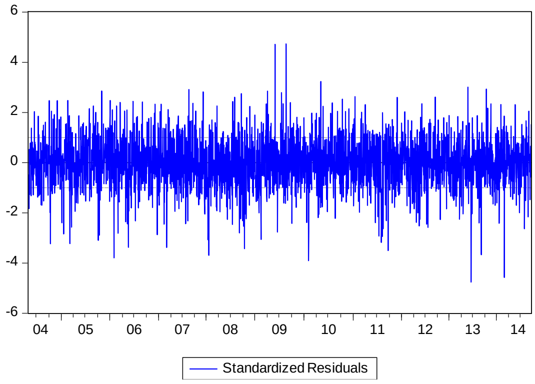
Romania



Hungary



Bulgaria



Poland

Figure no. 3 Standardized Residual Graph

Table no. 4 Autocorrelation for standardized residual squared

Lag	Romania		Hungary		Bulgaria		Poland	
	AC	**Q-Stat**	**AC**	**Q-Stat**	**AC**	**Q-Stat**	**AC**	**Q-Stat**
1	0.032	2.5518 (0.110)	0.014	0.4860 (0.486)	0.012	0.3262 (0.568)	-0.008	0.1554 (0.693)
2	-0.012	2.9094 (0.233)	-0.001	0.4894 (0.783)	-0.012	0.6807 (0.712)	-0.048	5.8730 (0.053)
3	0.014	3.3733 (0.338)	0.004	0.5232 (0.914)	-0.022	1.8231 (0.610)	0.004	5.9074 (0.116)
4	-0.033	6.1152 (0.191)	0.003	0.5473 (0.969)	0.002	1.8300 (0.767)	0.019	6.8079 (0.146
5	-0.020	7.1395 (0.210)	-0.012	0.9365 (0.968)	-0.028	3.7413 (0.587)	0.030	9.1110 (0.105)
6	-0.049	13.256 (0.039)	-0.004	0.9753 (0.987)	0.018	4.5599 (0.601)	-0.011	9.4409 (0.150)
7	-0.017	13.981 (0.052)	0.002	0.9911 (0.995)	-0.002	4.5723 (0.712)	0.014	9.9343 (0.192)
8	-0.041	18.241 (0.019)	-0.007	1.1329 (0.997)	-0.030	6.7956 (0.559)	0.000	9.9345 (0.270)
9	-0.017	18.977 (0.025)	-0.005	1.1889 (0.999)	-0.009	6.9832 (0.639)	0.016	10.553 (0.308)
10	-0.016	19.644 (0.033)	-0.007	1.3355 (0.999)	-0.001	6.9860 (0.727)	-0.001	10.557 (0.393)

p-values are reported in parentheses.