



Assessing Volatility Patterns using GARCH Family Models: A Comparative Analysis Between the Developed Stock Markets in Italy and Poland

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ABSTRACT

The main aim of this research paper is to conduct a comparative empirical study on the behavior of the stock markets in Italy and Poland. In this sense, it is examined the presence of volatility patterns using GARCH family models for the sample period from December 2008 to December 2022. The selected period covers a long-time interval, so that the effects of certain extreme events can be implicitly evaluated. Moreover, the selected stock markets are both included in the category of developed markets. Considering that Italy and Poland are both member states of the European Union it is relevant to also analyze the impact of events such as BREXIT or the conflict between Russia and Ukraine.

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1. Introduction

The FTSE MIB stock index tracks the performance of 40 stock market equities listed on Borsa Italiana and aims to mimic the main sector weights of the Italian stock market. The Borsa Italiana (BIT) Euronext Milan and Euronext MIV Milan market places are the sources of the index's constituent stocks. The index was developed to be suited for futures and options trading, to serve as a benchmark index for Exchange Traded Funds (ETFs), and to track high capitalization stocks on the Italian market. We perform a comparative interpretation for the stock markets of Italy and Poland by abstracting daily closing adjusted prices from December 2008 to December 2022. In order to achieve this, we use a sample of the WIG20 index, which is a modified capitalization-weighted index of 20 Polish stocks listed on the main market. For futures contracts listed on the Warsaw Stock Exchange, the index serves as the underlying instrument. On April 16, 1994, the base value was changed to be 1000.

However, in order to provide an overview on the selected stock markets, we highlight the fact that FTSE Russell recently released in September 2022 the official report on FTSE Equity Country Classification of Markets. Thus, stock markets are divided into the following main categories, such as: developed, advanced emerging, secondary emerging and frontier markets. In other words, both the stock markets from Italy and Poland are included in the category of developed markets.

In order to apply the GARCH (1, 1) model and an asymmetric GARCH model such as the EGARCH (1,1) model, over the sample period from December 2008 to December 2022 based on daily observations, we take into consideration the sample indices of the Italian and Polish stock markets.

2. Literature review

Bhowmik and Wang (2020) discussed about so called "unprecedented fluctuations" of stock markets considering the global economy dynamics while volatility connected with the stock market uncertainty but also with the behavior of potential investors. As a short retrospective, Engle (1982) has emerged the GARCH model, and this particular model was later developed by Bollerslev (1986), Nelson (1991) and Glosten et al. (1993) related to the structure of GJR-GARCH model. Engle (2001) examined the concept of volatility based on ARCH and GARCH models in terms of applied econometrics approach. Trivedi et al. (2021) suggested that volatility clustering patterns triggers certain possibilities such as for higher losses but also for higher returns on a stock market.

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Chirilă (2022) examined the dynamics of stock market in Poland in the context of COVID-19 pandemic using TVP-VAR method. Kacperska and Kraciuk (2021) analyzed certain aspects regarding the behavior of the stock markets in Poland and Germany during the COVID-19 pandemic. Moreover, Kubiczek and Tuszkievicz (2022) investigated the impact of liquidity on the Polish stock market in the context of COVID-19 pandemic.

Keliuotyte - Staniuleniene and Kviklis (2022) have conducted a research study focusing on the impact of COVID-19 pandemic on some of the most seriously affected member countries of the European Union, such as Italy and Spain. Spulbar et al. (2022) investigated the volatility clustering and patterns for the developed stock market from Japan using GARCH models for the sample period from July 1998 to January 2022. In addition, Birau et al. (2021) examined volatility spillover effect on developed stock markets of Spain and Hong Kong using GARCH models for the selected period from January 2015 to September 2021.

3. Research methodology

The main objective of this paper is to establish how volatility clusters, patterns, and shocks have been altered over the selected long-period with comparative interpretation between Italy and Poland stock markets, for this purpose, the respective benchmark indexes are used, such as the FTSE MIB index and WIG 20 index. For comparative volatility estimation, we employ the Bollerslev (1986) GARCH (1, 1) model to series returns and the asymmetric GARCH, Exponential GARCH model by Nelson (1991). The data are translated using log-returns.

Bollerslev's GARCH (1, 1) is demonstrated;

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

Formula process contains mean equation and variance equation represented as the following:
Mean equation is the following:

$$r_t = \mu + \varepsilon_t$$

Variance equation is the following:

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

The GARCH (1, 1) model analyzes volatility dynamics and postulates that if the product of the coefficients for ARCH and GARCH is equal to 1, then any shock, whether positive or negative, can permanently alter all future values. In the absence of this, conditional variance shock will be categorised as persistent in nature. Graphs with explanations of the specifics are used to depict actual series returns, volatility shocks, and comparative asset returns for Austria, France, Germany, and Spain. Nelson (1991) presented the exponential GARCH or EGARCH to reflect the asymmetric impact in the series returns.

$$\text{Log}(\sigma_t^2) = \omega + \sum_{j=1}^p \beta_j \text{Log}(\sigma_{t-j}^2) + \sum_{j=1}^q \alpha_j \left(\frac{\varepsilon_{t-j}}{\sigma_{t-j}} \left| -\frac{\sqrt{2}}{n} \right| - y_j \frac{\varepsilon_{t-j}}{\sigma_{t-j}} \right)$$

This model uses a long form and adds a term we call the "asymmetric effect" to describe the leverage effects.

First, we convert the actual returns into the log returns and consider the first difference to test the stationarity in the sample indices. For that purpose we use;

$$\text{Return} = \ln\left(\frac{P_t}{P_{(t-1)}}\right) * 100$$

Further to test the normality, Augmented Dickey Fuller test is used.

$$(1 - L)y_t = \beta_0 + (\alpha - 1)y_{t-1} + \varepsilon_t$$

The ADF test results are as follows; Augmented Dickey-Fuller test for FTSE – MIB and WIG 20, testing down from 4 lags, criterion AIC and daily observations with sample size 3511. We find that at unit-root null hypothesis: $\alpha = 1$, using the test with constant and including 3 lags of (1-L), model: $(1-L)y = b_0 + (\alpha-1)y(-1) + \dots + e$, estimated value of $(\alpha - 1)$: -0.920405 and -0.897224 for Italy (FTSE – MIB) and Poland (WIG 20) respectively. ADF test confirms no unit root and the series are stationary to model the generalized autoregressive conditional heteroscedasticity (GARCH) class models.

4. Empirical analysis and results

Variance Matrix Proportions Data matrices with huge numbers will have overall larger eigenvalues than those with tiny numbers. Scaling the columns of X to one unit length will eliminate the scaling effect described by Belsley et al. (1980), whose collinearity diagnostic approach is suggested here. This scale is not used for model estimation or interpretation, solely for the purpose of diagnosing collinearity.

$$\text{tr}(X^T X) = \sum_{k=1}^k \lambda_i.$$

Condition Variance Proportions of OLS

Index $\text{var}(b_1) \text{var}(b_2) \dots \text{var}(b_k)$

$\eta_1 \varphi_{11} \varphi_{12} \dots \varphi_{1k}$

$\eta_1 \varphi_{21} \varphi_{22} \dots \varphi_{2k}$

$\eta_k \varphi_{k1} \varphi_{k2} \dots \varphi_{kk}$

Belsley-Kuh-Welsch collinearity and the coefficient of variation of the variables under consideration are diagnostic. From auxiliary centred (with intercept) and noncentered (without intercept) regressions, we evaluate the diagnostic of near-multicollinearity in a multiple linear regression.

Table 1. Belsley-Kuh-Welsch collinearity diagnostics: variance proportions

	lambda	cond	constd	d_l_FTSE~	d_l_WIG2~
	1.031	1.000	0.038	0.486	0.445
	1.000	1.015	0.916	0.000	0.083
	0.969	1.032	0.046	0.514	0.471

lambda = eigenvalues of inverse covariance matrix (smallest is 0.968886)

cond = condition index

note: variance proportions columns sum to 1.0

According to BKW, $\text{cond} \geq 30$ indicates "strong" near linear dependence, and Cond between 10 and 30 "moderately strong". Parameter estimates whose variance is mostly associated with problematic Cond values may themselves be considered problematic.

Count of condition indices ≥ 30 : 0

Count of condition indices ≥ 10 : 0

One divided by the tolerance, which is one less than R-squared, yields the value of the VIF. The VIF for volume in this situation would be $1/(1-0.584)$, or 2.4. There is no multicollinearity for a variable if its VIF is one. No evidence of excessive collinearity found between Italian stock market and Poland stock market with the sample data from December 2008 to December 2022.

The summary of statistics exhibited in Table 2, provides information that Italian stock market created positive returns for the investors over a period of time, whereas the Poland stock market with negative returns. However, both of the selected sample markets have negatively skewed returns with excess kurtosis.

Table 2. Summary Statistics, using the observations 2008-12-18 - 2022-12-23

Variable	Mean	Median	Minimum	Maximum
FTSE - MIB	0.00013151	0.0011381	-0.17115	0.065474
WIG 20 - Poland	-5.2135e-006	0.00040762	-0.13595	0.081694
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
FTSE - MIB	0.014674	111.58	-0.88673	8.7682
WIG 20 - Poland	0.013609	2610.4	-0.95504	10.442
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
FTSE - MIB	-0.023788	0.022292	0.015223	1
WIG 20 - Poland	-0.020849	0.019947	0.013102	1

Source: Author's computation using first log difference of selected variables

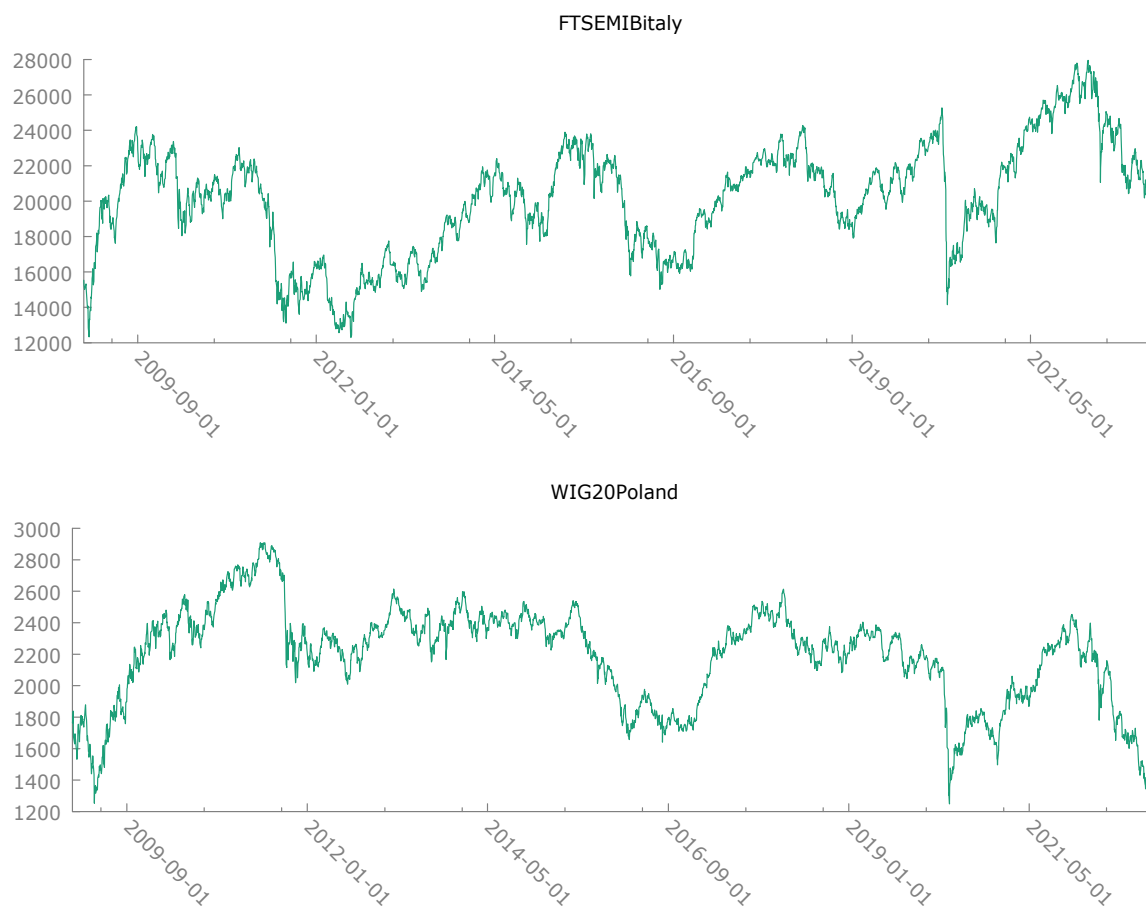


Figure 1. Actual movements of Italian and Poland Stock markets

Source: Author's computation

Selected samples of Italian and Poland stock markets demonstrate the movement of index from December 2008 to December 2022 considering the daily observations. We observe the rapid recovery from the global financial crisis with the beginning of January 2009 where the Italian stock market does not have correction shocks as the same appears with the Poland stock market. However, it is important to note that Poland stock market has more number of positive shocks during the period from 2009 to 2012 (refer Figure 1). The Figure 2 exhibits the volatility shocks (stationary series returns) where the impact of COVID-19 pandemic appears clearly. It is important to note that since both of the stock markets have reacted to the COVID-19 pandemic situations, however, the Italian stock market did not reached fall to the global financial crisis level, whereas the Poland stock market merely approached to trading level of global financial crisis (refer Figure 2).

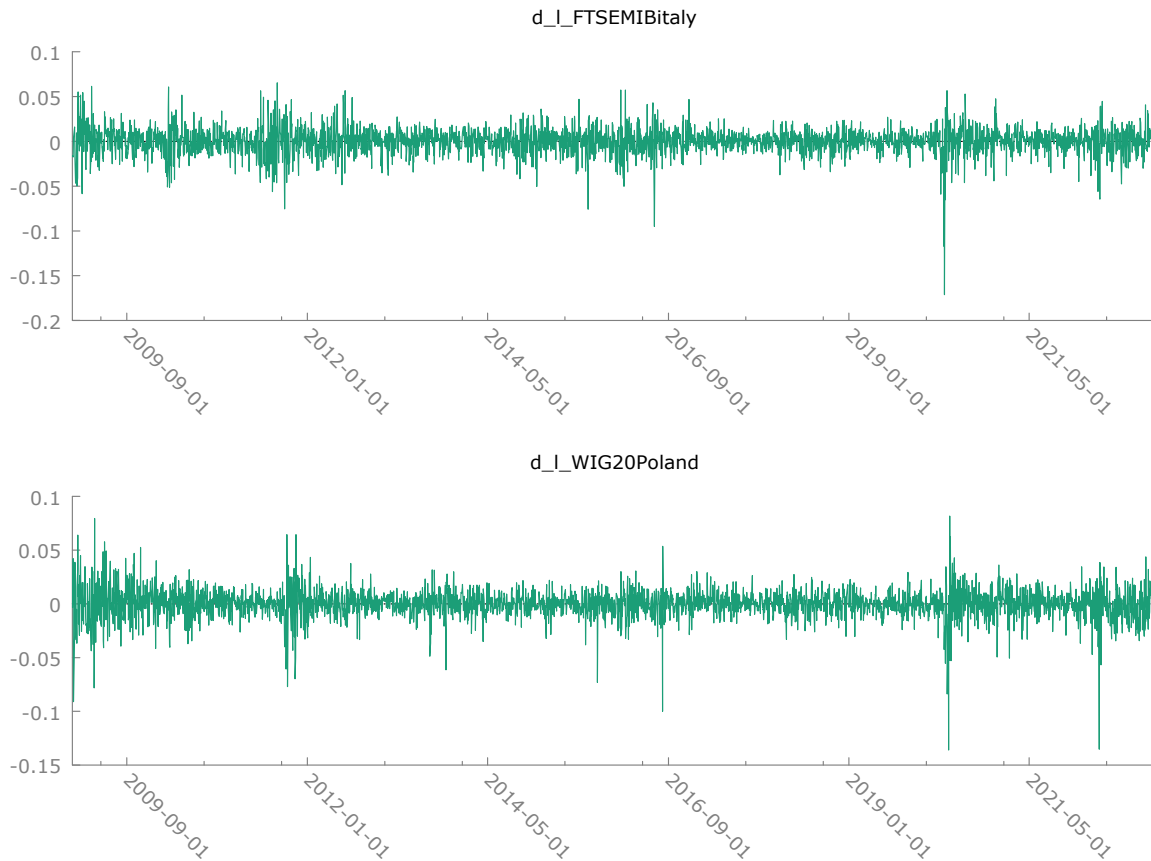


Figure 2. Volatility Sketches and Stationary returns for Italy and Poland for the sample period

Source: Author's computation

Table 3 Model: GARCH(1,1) [Bollerslev] (Normal)*

Dependent variable: d_I_FTSEMIBitalySample: 2008-12-19 -- 2022-12-23 (T = 3515), VCV method: Robust

Conditional mean equation				
coefficient	std. error	z	p-value	

const	0.000436815	0.000202757	2.154	0.0312 **
Conditional variance equation				
coefficient	std. error	z	p-value	

omega	4.75515e-06	1.67094e-06	2.846	0.0044 ***
alpha	0.0918819	0.0179764	5.111	3.20e-07 ***
beta	0.886273	0.0223698	39.62	0.0000 ***
Llik: 10250.68321		AIC: -20493.36642		
BIC: -20468.70724		HQC: -20484.56777		

Source: Author's computation using the first log difference of selected samples

Table 4 Model: GARCH(1,1) [Bollerslev] (Normal)*

Dependent variable: d_I_WIG20Poland
Sample: 2008-12-19 -- 2022-12-23 (T = 3515), VCV method: Robust

Conditional mean equation				
coefficient	std. error	z	p-value	

const	0.000128924	0.000177680	0.7256	0.4681
Conditional variance equation				

coefficient	std. error	z	p-value
omega	4.03682e-06	1.33352e-06	3.027 0.0025 ***
alpha	0.0987565	0.0218277	4.524 6.06e-06 ***
beta	0.880144	0.0246728	35.67 1.05e-278 ***
Llik: 10633.95631		AIC: -21259.91261	
BIC: -21235.25343		HQC: -21251.11396	

Source: Author's computation using the first log difference of selected samples

Table 5. Model: EGARCH(1,1)
 Dependent variable: d_l_FTSE MIB - Italy
 VCV method: Robust

Conditional mean equation

coefficient	std. error	z	p-value
const	-3.47644e-05	0.000131017	-0.2653 0.7907

Conditional variance equation

coefficient	std. error	z	p-value
omega	-0.288323	0.0650506	-4.432 9.32e-06 ***
alpha	0.120257	0.0208972	5.755 8.68e-09 ***
gamma	-0.109847	0.0141402	-7.768 7.95e-015 ***
beta	0.977413	0.00623592	156.7 0.0000 ***
Llik: 10324.23701		AIC: -20638.47403	
BIC: -20607.65006		HQC: -20627.47571	

Source: Author's computation using the first log difference of selected samples

Table 6. Model: EGARCH(1,1)
 Dependent variable: d_l_WIG20 Poland
 VCV method: Robust

Conditional mean equation

coefficient	std. error	z	p-value
const	-0.000125031	0.000186303	-0.6711 0.5021

Conditional variance equation

coefficient	std. error	z	p-value
omega	-0.299711	0.0619387	-4.839 1.31e-06 ***
alpha	0.148995	0.0278498	5.350 8.80e-08 ***
gamma	-0.0747323	0.0120722	-6.190 6.00e-010 ***
beta	0.978962	0.00529969	184.7 0.0000 ***
Llik: 10684.74388		AIC: -21359.48777	
BIC: -21328.66379		HQC: -21348.48945	

Source: Author's computation using the first log difference of selected samples

5. Conclusions

Since the GARCH process is nonlinear, the corresponding state-space formulation will exhibit a similar pattern of behaviour. For the Italian and Polish stock markets, GARCH provides well-fitting and precise forecasts. Although asymmetric GARCH model is favoured for fluctuation (crisis) periods, symmetric GARCH model (GARCH 1, 1) performs better than the latter. For Italy and Poland, respectively, Tables 3 and 4 offer model parametric for GARCH (1, 1). The results of the EGARCH (1, 1) model estimation are shown in Tables 5 and 6. GARCH (1, 1) fitted with 5% significance level for FTSE – MIB index, Italy stock market indicates persistence in the volatility. Conditional mean equation for the Poland stock market sample (WIG 20 index) is not significant. Further, conditional mean equation not fitted also for Exponential GARCH (EGARCH) model for both of the sample markets.

The conditional variance parametric for EGARCH indicates that both of the sample markets have existence of leverage effect for the selected time period, resulting long effect for the negative shocks than the positive. The subject of estimating stock market volatility interests both investors and researchers, but it also attracts general interest. These opportunities are now possible because of developments in econometric modelling. The application of GARCH (1,1) model and asymmetric GARCH model or EGARCH model is the main topic of this research study. We find that the stock market in Poland did not provide any value for investors as the long term mean returns are negative due to the market's tendency to perform at a level below that of the global financial crisis. Additionally, negative shocks happen more frequently than positive ones due to the uneven impact of these two markets. Leverage impact was also noted in the stock markets of Poland and Italy. There is no evidence of collinearity between Italian and Poland stock markets for the selected sample period.

References

1. Bhowmik, R., Wang, S. (2020) Stock Market Volatility and Return Analysis: A Systematic Literature Review, *Entropy*, 22(5):522, <https://doi.org/10.3390/e22050522>.
2. Birau, R., Spulbar, C., Trivedi, J., Florescu, I. (2021) Modeling volatility in the stock markets of Spain and Hong Kong using GARCH family models in the context of COVID - 19 pandemic, *Revista de Științe Politice. Revue des Sciences Politiques*, 72, 3 – 21.
3. Bollerslev, T. (1986) Generalized autoregressive conditional heteroskedasticity, *Journal of Econometrics*, 31(3), 307-327.
4. Chirilă V. (2022) Connectedness between Sectors: The Case of the Polish Stock Market before and during COVID-19, *Journal of Risk and Financial Management*, 15(8), 322. <https://doi.org/10.3390/jrfm15080322>.
5. Engle, R. (1982) Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of UK Inflation, *Econometrica*, 50, 987-1008.
6. Engle, R. (2001) GARCH 101: The Use of ARCH/GARCH Models in Applied Econometrics, *Journal of Economic Perspectives, American Economic Association*, vol. 15(4), pages 157-168, <https://www.aeaweb.org/articles?id=10.1257/jep.15.4.157>.
7. Glosten, L., Jagannathan, R., Runkle, D. (1993) On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks. *The Journal of Finance*, 48(5), 1779-1801. <https://doi.org/10.1111/j.1540-6261.1993.tb05128.x>.
8. Kacperska, E., Kraciuk, J. (2021) Changes in the Stock Market of Food Industry Companies during the COVID-19 Pandemic - A Comparative Analysis of Poland and Germany, *Energies*, 14(23), 7886, <https://doi.org/10.3390/en14237886>.
9. Keliuotyte-Staniulieniene, G., Kviklis, J. (2022) Stock Market Reactions during Different Phases of the COVID-19 Pandemic: Cases of Italy and Spain, *Economies*, 10(1):3. <https://doi.org/10.3390/economies10010003>.
10. Kubiczek, J., Tuskiewicz, M. (2022) Intraday Patterns of Liquidity on the Warsaw Stock Exchange before and after the Outbreak of the COVID-19 Pandemic, *International Journal of Financial Studies*, 10(1), 13, <https://doi.org/10.3390/ijfs10010013>.
11. Nelson, D. (1991) Conditional heteroskedasticity in asset returns: A new approach. *Econometrica*, 59(2), 347-370. <https://doi.org/10.2307/2938260>.
12. Spulbar, C., Birau, R., Trivedi, J., Hawaldar, I.T., Minea, E.L. (2022). Testing volatility spillovers using GARCH models in the Japanese stock market during COVID-19. *Investment Management and Financial Innovations*, 19(1), 262-273. doi:10.21511/imfi.19(1).2022.20.
13. Trivedi, J., Afjal, M., Spulbar, C., Birau, R., Inumula, K.M., Pradhan, S. (2021) Modeling emerging stock market volatility using asymmetric GARCH family models: An empirical case study for BSE Ltd. (formerly known as Bombay Stock Exchange) of India, *Revista de Științe Politice. Revue des Sciences Politiques*, No. 70, 167 – 176.
14. *** - <https://www.ftserussell.com/equity-country-classification>.