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ORIGINAL PAPER

Investigating stylized facts and long-term volatility patterns using GARCH models: An empirical case study for the Russian stock market

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Abstract:
This research paper investigates the behaviour of Russian stock market for the sample period from January 2000 to April 2022. The econometric approach is based on the application of GARCH family models and on various tests and statistical methods. This empirical research also examines stylized facts and long-term volatility patterns for the Russian stock market. The empirical analysis was also focused on revealing the dynamics of the selected stock market under the impact of certain extreme events, such as: the recent conflict between Russia and Ukraine, the COVID – 19 pandemic, the global financial crisis (GFC) of 2007 - 2008.

Keywords: *volatility pattern; GARCH models; stock market; stylized facts; COVID – 19 pandemic; global financial crisis (GFC).*

JEL Classifications: G14, E00

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1. Introduction

The recent pandemic has had a significant impact on the evolution of financial markets all around the world which implicitly affects sustainable economic growth perspective. Qaiser Gillani et al. (2021) also revealed that health represents an essential pillar in order to achieve sustainable development. Nayak et al. (2021) highlighted the linkage between Government expenditure and economic growth in the case of another emerging country which also included in BRICS, such as India. Sohag et al. (2022) suggested that geopolitical disruption generates an impact on stock market synchronization caused by investors' emotional (sentimental) feedback. As a result, Russia's stock market indices have fallen sharply in the context of the turmoil in Ukraine and the annexation of Crimean Peninsula from Ukraine by Russia in 2014. Pourmansouri et al. (2022) examined the relation between major shareholders and corporate governance in the turbulent context of COVID-19 Pandemic, both before and after this extreme event.

2. Literature review

Hartwell (2021) investigated the impact of political violence on Russian stock market behaviour for a long time period of over 50 years in the 19th century of Tsarist Russia based on the sample period from January 1865 to July 1914 (monthly data). The empirical findings revealed that the St. Petersburg Stock Exchange, as the Russian stock market was called at the time of the analysis, has reached weak efficiency regarding information processing but still affected by uncertainty such as political violence extreme events. On the other hand, Aktan et al. (2019) examined essential aspects on stock market efficiency in its week form based on a cluster of 32 markets divided into three main categories such as frontier, emerging and developed, all from Europe for the sample period June 2006 - June 2017 and stated that markets can be inefficient during times of stress.

Sohag et al. (2022) addressed key issues regarding the concept of stock market synchronization considering the implications for investment strategies based on international portfolio diversification for a cluster which included selected stock markets from US, China and Russia. Ben Nasr et al. (2018) examined country risk ratings in the case of BRICS stock market returns and identify the highest historical volatility in Russian stock market which makes it more difficult to predict market behaviour. Moreover, Balcilar et al. (2017) have conducted an empirical study on geopolitical uncertainty by modeling the behaviour of BRICS stock markets and considered that Russia is exposed to the greatest risks from both geopolitical risk perspectives, such as stock returns and volatility. Birau et al. (2021) examined the dynamics of certain stock markets such as Spain and Hong Kong by applying GARCH models for a sample period which is focused on the impact of COVID - 19 pandemic.

3. Data collection and research methodology

This research study tests the changes in the volatility pattern, presence of leverage effect and discuss empirically the impact of good news and bad news using symmetric and asymmetric GARCH class models using daily closing prices for MOEX – Russia, one of the leading stock exchange to capture the changes in volatility clusters and explore how investors approached with recent political changes. We use ADF to test presence of leverage effect considering the first difference of log-returns, GARCH (1, 1)

by Bollerslev (1986) and asymmetric GARCH class models such as Exponential GARCH, Nelson (1991) that captures the presence of asymmetry in the series returns. For this purpose, the sample returns considered from January 2000 to April 2022 consisting 5803 observations. The data abstracted from Bloomberg. To execute this objectives, study adopts the following process:
Log conversion;

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) = \ln(p_t) - \ln(p_{t-1})$$

ADF regression process;

$$\Delta y_t = c + \beta \cdot t + \delta \cdot y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t$$

ADF process;

$$(1 - L)yt = \beta 0 + (\alpha - 1)yt - 1 + \varepsilon i$$

Symmetric GARCH (1, 1);

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

Generalized Autoregressive Conditional Heteroscedastic is generalized version of ARCH model by Engle. GARCH (1, 1) processes 1 ARCH effect and 1 GARCH effect.
Processing Mean and Variance equations;
Mean equation;

$$rt = \mu + \varepsilon t$$

Mean equation indicates sum of average return denoted by (μ) that is returns of asset in time (t), and residual return denoted by (εt).
Variance equation;

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

Variance equation assumption process assures that value of constant is higher than 0, following the value of $\alpha + \beta$
GARCH (1, 1) represents symmetric model that is extensively used to estimate volatility in time series returns.
EGARCH also called Exponential GARCH. EGARCH by Nelson (1991) captures asymmetric responses of time-vary variances to volatilty shocks and also ensures that variance is always positive.

$$Log(\sigma_t^2) = \omega + \sum_{j-i}^{p} \beta i \, Log(\sigma_{t-i}^2) + \sum_{j-1}^{q} \alpha i \left\langle \frac{\varepsilon i - t}{\sigma}_{i-t} \left| - \frac{\sqrt{2}}{n} \right| - yi \frac{\varepsilon i - t}{\sigma i - t} \right\rangle$$

4. Empirical results and discussion

Property of descriptive statistics exhibited in table 1 (refer table 1). Further the actual series movement plot captured and presented in Figure 1, followed by the stationary returns (first log difference) which is tested with ADF, testing down from 4 lags, criterion AICsample size 5801 and found unit-root null hypothesis: a = 1, confirming series stationary with constant where, including 0 lags of (1-L), expanding model (1-L)y = b0 + (a-1)*y(-1) + e, found estimated value of (a - 1): -0.998007 and test statistic: tau_c(1) = -76.2644 suggesting asymptotic p-value 0.0001. Russian specimen index series returns provides negative skewness with excess degree of kurtosis, creating leptokurtic impact with long fat left tail.

Table 1
Summary Statistics, using the observations 2000-01-04 - 2022-04-29
for the variable MOEX Index – Russia (5802 valid observations)

Mean	Median	Minimum	Maximum
0.00048	0.00032	-0.4047	0.25226
Std. Dev.	C.V.	Skewness	Ex. kurtosis
0.02009	41.935	-1.4882	43.466
5% Perc.	95% Perc.	IQ range	Missing obs.
-0.0277	0.02719	0.01629	1

Source: Authors computation using first log difference of daily closing prices

The data from first day trading in the month of January 2000 to last trading day in the month of April, 2022 where lowest trading index was at level 131 and created high of 4287 just before the invasion to Ukraine. Such political movement responded by the investors which appears in property of Figure 1, creating sudden down slop from trading level of above 4100 to merely 2000 trading level. The aggressive recovery also captured. Property of Figure 2 captures the volatility clusters for the Russian stock market index suggesting several negative and positive shocks, where the war impact generated shocks four times greater than the impact of novel Coronavirus (COVID - 19) and the global pandemic, also double than the global financial crisis impact.

Figure 1 – Actual series returns - MOEX – Russia from 2000-01-04 - 2022-04-29

Figure 2 Log-returns (Volatility Clusters) MOEX – Russia 2000-01-04 - 2022-04-29

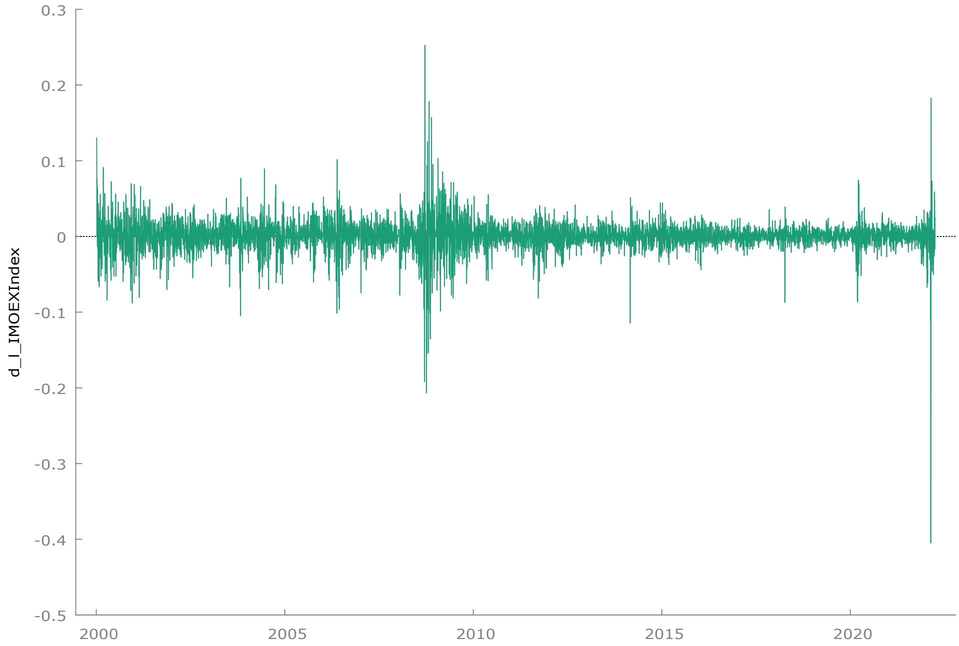
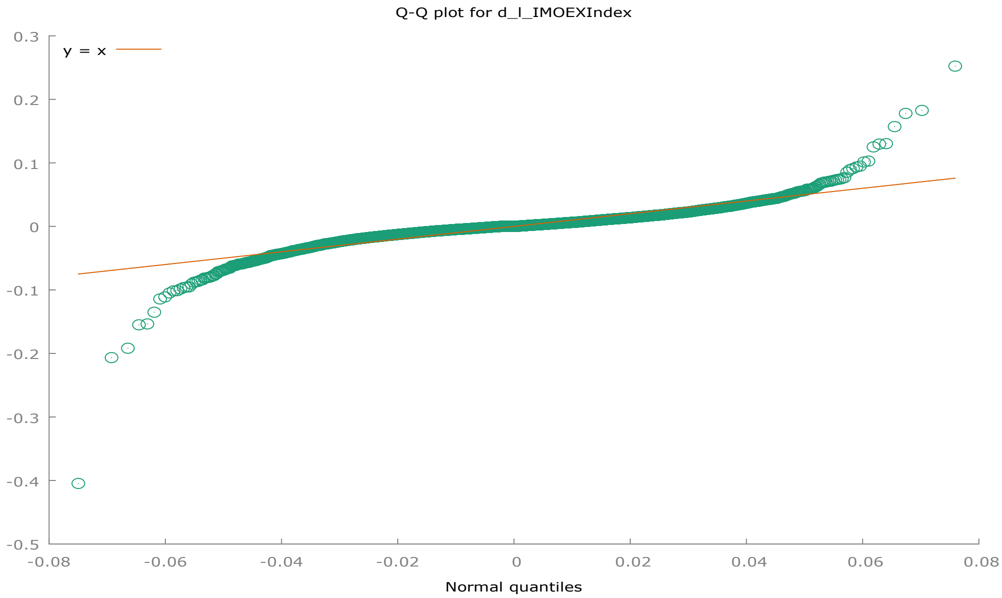


Figure 3 Quantile Plot, MOEX – Russia from 2000-01-04 - 2022-04-29



Source: Authors computation using first log difference of daily closing prices from 2000-01-04- 2022-29-04

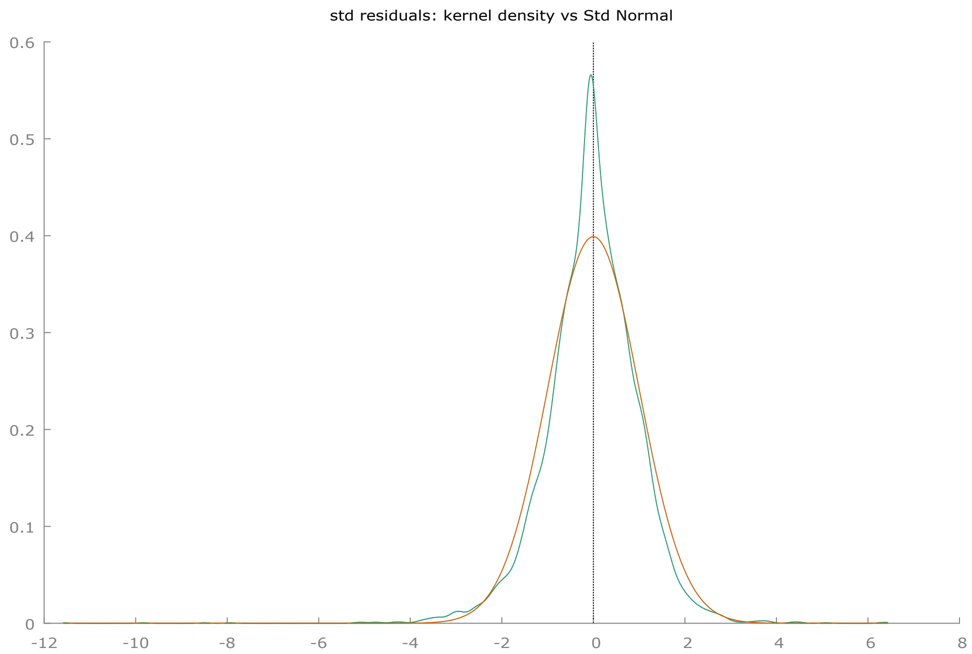
The quantile plot (refer figure 3) indicates how the returns switched from positive to negative stretching left long tail with negative magnitude shocks up to 0.4 magnitudes, which is amongst the double than the highest ever positive shocks in the Russian stock market index (0.2) across the sample period of over twenty-two years.

Table – 2
Model: GARCH(1,1) [Bollerslev] (Normal)*, Dependent variable: d_l_IMOEXIndex
Sample: 2000-01-04 -- 2022-03-30 (T = 5802)

	coefficient	std. error	z	p-value
Conditional mean equation				
const	0.00092	0.0002	4.532	5.83e-06 ***
Conditional variance equation				
omega	4.31E-06	1.92E-06	2.252	0.0243 **
alpha	0.10281	0.02403	4.278	1.88e-05 ***
beta	0.88879	0.02462	36.09	2.84e-285 ***
Llik: 16040.53945			AIC: -32073.07891	
BIC: -32046.41508			HQC: -32063.80369	

Source: Authors computation using first log difference of daily closing prices from 2000-01-04- 2022-29-04

Figure 4 GARCH (1, 1) Positioning of standard residuals for MOEX - Russia



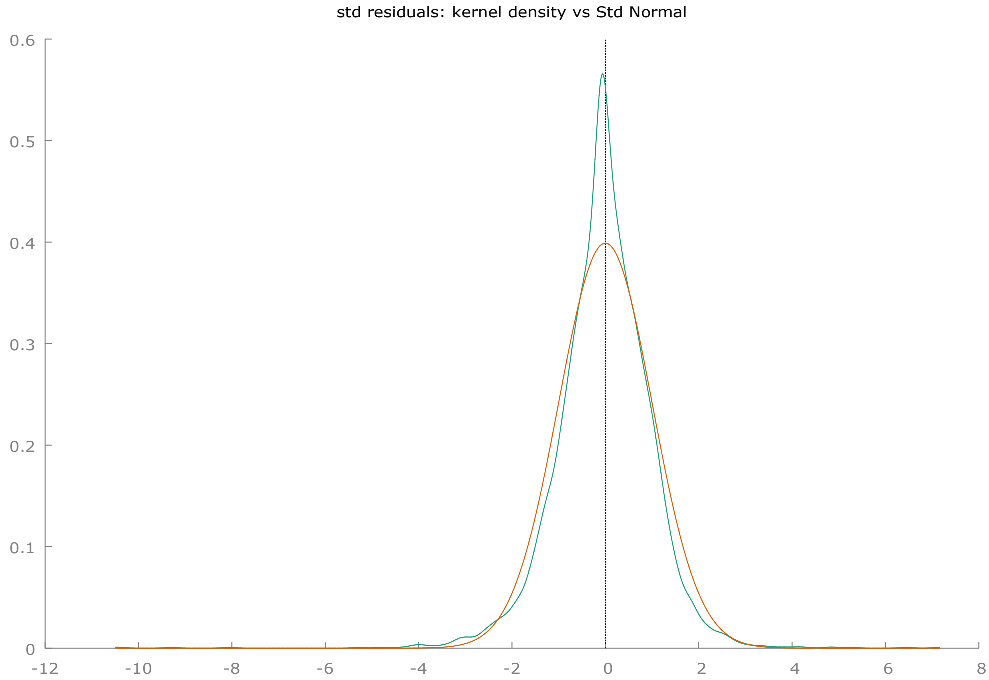
Source: Authors computation using first log difference of daily closing prices from 2000-01-04- 2022-29-04

Table 3 Exponential GARCH for MOEX Russia, Model: EGARCH(1,1) [Nelson] (Normal) Dependent variable: MOEX – Russia, Sample: 2000-01-04 -- 2022-04-29 (T = 5802), VCV method: Robust

Conditional mean equation				
	coefficient	std. error	z	p-value
const	0.001	0.0002	4.851	0.00000123 ***
Conditional variance equation				
omega	-0.271	0.07632	-3.551	0.0004 ***
alpha	0.18209	0.03801	4.791	1.66e-06 ***
gamma	-0.0489	0.01674	-2.919	0.0035 ***
beta	0.98356	0.00654	150.5	0.0000 ***
Llik: 16015.79099			AIC: -32021.58199	
BIC: -31988.25220			HQC: -32009.98796	

Source: Authors computation using first log difference of daily closing prices from 2000-01-04- 2022-29-04

Figure 5 EGARCH (1, 1) standard residuals positioning



Source: Authors computation using first log difference of daily closing prices from 2000-01-04- 2022-29-04

The model designed by Bollerslev (1986), such as GARCH (1, 1) which consist effect of one ARCH and a GARCH fitted perfectly on the series returns of MOEX – Russia. The outcome property suggests that volatility is highely persistent in nature for the selected samples of Russian stock exchange. The sum of $\alpha + \beta = 0.9916$ indicating that volatility absorbs past events at least at 88.87% of the previous impact followed in future movements. The asymmetric GARCH model, i.e. Exponential GARCH by Nelson (1981) fitted perfectly on the series returns and confirms the presence of leverage effect suggesting that Russian stock market indicated by the (γ). The EGARCH also provides forecast that good news effects the Russian stock market at magnitude of 18.20% whereas the bad news effects 23.09%, further with having presence of leverage effect in the series returns, it indicates that large negative shocks will followed by more number of negative shocks, but in case of positive shocks, the market will not react equally for the following movements.

We have demonstrated evidence the MOEX, Russian stock market index absorbed the global political movement by the Russia which has impacted four times more than the impact of global pandemic of novel Coronavirus (COVID-19) and almost double strong than the global financial crisis impact. The returns approached to sharp negative from all time high trading level creating sharp (A) pattern followed by sharp positive that created (V) pattern (refer Figure 1) indicating that investors expecting aggressive recovery of previous loss.

4. Conclusions

We tested movement pattern capturing the recent political movement by Russia in to the Ukraine, fitness of symmetric and asymmetric GARCH class models on the series returns and volatility clusters. We found that GARCH and EGARCH fitted perfectly at significance level of 1% suggesting persistent in the volatility pattern with presence of asymmetry. The summary of statistics provided important information that mean returns are negative in nature, further there is least possibility to have any positive gain in case purchased today and sell tomorrow, the kurtosis is far exceeding the normal parameter and creating leptokurtic impact with left long tail. Considering the present model estimation, there are prospective opportunity for the long-term investors with the high degree of risk factor since the market seems to be moving in a dynamic form of creating sharp (V) shape for the stock returns. The empirical results added additional empirical evidence to the existing literature.

Authors' Contributions:
The authors contributed equally to this work.

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