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ORIGINAL PAPER

Abstracting Volatility Dynamics of South Korean Stock Market: A case study

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Abstract:
The main aim of this research paper is to investigate the volatility dynamics of South Korean stock market. The sample data covers the long time period from December 1996 to September 2022, which also includes certain extreme events such as: the Asian financial crisis of 1997, the global financial crisis of 2008, the COVID-19 pandemic, the war between Russia and Ukraine. The econometric approach focuses on GARCH models and certain statistical tests. The empirical results contribute to the existing specialized literature.

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1. Introduction

South Korea among with Hong Kong, Singapore and Taiwan represents the Four Asian Tigers or the Four Asian Dragons which are a cluster of rapid growth economies in Asia. Moreover, South Korea is part of the East Asian Miracle. According to the most recent FTSE Russell Equity Country Classification report released in September 2022, South Korea is included in the category of developed stock markets.

Perez (2018) examined the behavior of South Korean stock market considering the rather unique characteristics of this economy which seems to be unequivocally categorized as neither developed nor developing. Lee et al. (2019) argued that in recent past the significance of corporate sustainability reached increasing levels in Korea. In addition, Thorbecke (2021) conducted an empirical research study on the firms in France and South Korea regarding stock returns and concluded that the economy in Korea is less exposed to appreciations compared to the economy in France.

2. Literature review

Perez (2018) argued that the stock market of South Korea highlights a performance in what concerns value investment aspect that differentiates it from other economies. Spulbar et al. (2022) examined volatility spillovers for the stock market in Japan using NIKKEI 225 index for the long time sample period from July 30, 1998, to January 24, 2022, i.e. including during the COVID-19 pandemic based on GARCH models. In addition, Trivedi et al. (2022) analyzed the behavior of Russian stock market for the sample period from January 2000 to April 2022 using GARCH models while considering certain extreme events such as the recent war between Russia and Ukraine, the COVID–19 pandemic, but also the global financial crisis of 2007-2008. Thorbecke (2021) investigated the impact of exchange rate and COVID-19 pandemic news on the French and South Korean economies.

According to Lee et al. (2019) “changes in risk or liquidity of an asset result in changes in returns “even considering the “Green Growth” policy of the Korean government authorities. Eom et al. (2022) investigated volatility interruptions in the case of Korean stock markets which is very important approach considering abnormal volatility patterns for individual financial stocks. Choi and Yoon (2020) examined the linkage between investor sentiment and herding behavior in the case of Korean Stock Market, i.e. KOSPI and KOSDAQ stock markets, which is an important aspect considering the decision-making process of investors. Badarla et al. (2022) examined the behaviour of certain stock markets, such as: Switzerland, Austria, Hong Kong and China based on GARCH models for the sample period January 2003 up to September 2021.

3. Research methodology and empirical analysis

This research paper captures the changes in volatility parameter, movement behavior of selected sample of South Korean financial market index, (KOSPI), daily closing price from December 1996 to September 2022 consisting 6360 daily observations. For this purpose we used Generalized Autoregressive Conditional Heteroskedasticity (GARCH) class models; GARCH (1, 1) model, EGARCH model and GJR model to estimate the presence of leverage effect. First, the databases are converted to first difference of log-returns and tested with normality using ADF, JB tests. The main equations are as follows:

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;

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

Jarque-Bera test:

$$JB = n\left[\frac{s^2}{6} + \frac{(k-3)^2}{24}\right] = \frac{n}{6} \cdot (s^2 + \frac{(k-3)^2}{4})$$ And;

$$s = \frac{\hat{\mu}_3}{\hat{\sigma}^3} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{[\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2]^{\frac{3}{2}}} \quad k = \frac{\hat{\mu}_4}{\hat{\sigma}^4} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{\left[\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right]^2}$$

Symmetric GARCH (1, 1) model isused as following:

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

The generalised form of Engle's ARCH model is called generalised Autoregressive Conditional Heteroscedastic. One ARCH effect and one GARCH effect are processed by GARCH (1, 1) processing the formulae for Mean and Variance, but also 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;

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

The procedure of making the assumption about the variance equation ensures that the constant value is greater than 0. The value of α+β. GARCH (1, 1) model reflects a symmetric model that is often used to evaluate volatility in time series returns. One of the drawbacks of symmetric models is that they are unable to account for the leverage effect, which necessitates the addition of lags and exponential processes. As a result, asymmetric GARCH type models, such as EGARCH, also known as Exponential

GARCH, are needed. By ensuring that variance is always positive, Nelson's EGARCH (1991) model captures the asymmetric reactions of time-varying variances to volatility shocks.

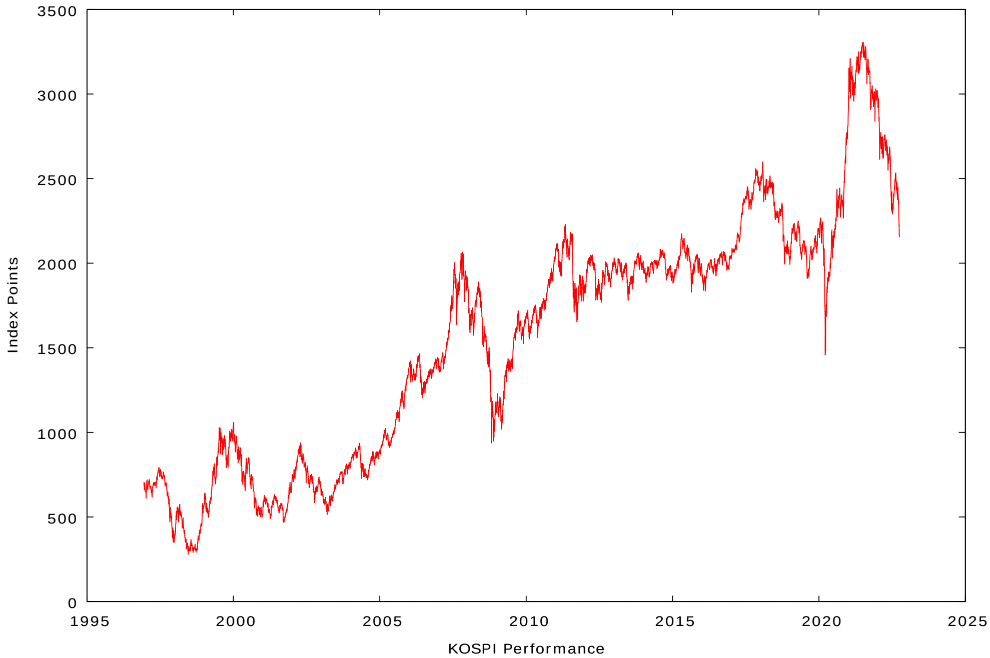
$$Log(\sigma_t^2) = \omega + \sum_{j-i}^{p} \beta i \; Log(\sigma_{t-i}^2) + \sum_{j-1}^{q} \alpha i \left(\left| \frac{\varepsilon\, i-t}{\sigma \;\; i-t} \right| - \sqrt{\frac{2}{\pi}} \right) + \gamma i \frac{\varepsilon\, i-t}{\sigma\, i-t}$$

Another asymmetric model, GJR, which was created by Glosten, Jagannathan, and Runkle in 1993 as a version of the Threshold GARCH, also measures stylized facts like the leverage effect and the impact of news on stock markets. Only regression in the mean equation, which is constant, is present in this model.

$$ht = \delta + \alpha_1 e_{i-1}^2 + \gamma d_{i-1} e_{t-1}^2 + \beta_i h_{i-1}$$

Where dt represents two cases in case of 1 and 0, where et <0, create bad news and 0, et > 0 indicates good news. Further the value of alpha, Gamma and Beta are non-negative parameters satisfying condition like EGARCH model in otherwise manner. The random-walk series movement exhibited in Fig-1. Augmented Dickey Fuller (ADF) statistics provides details about the stationarity of the series returns after considering the first log difference of series returns.

Fig – 1 Random-Walk movement pattern of – KOSPI

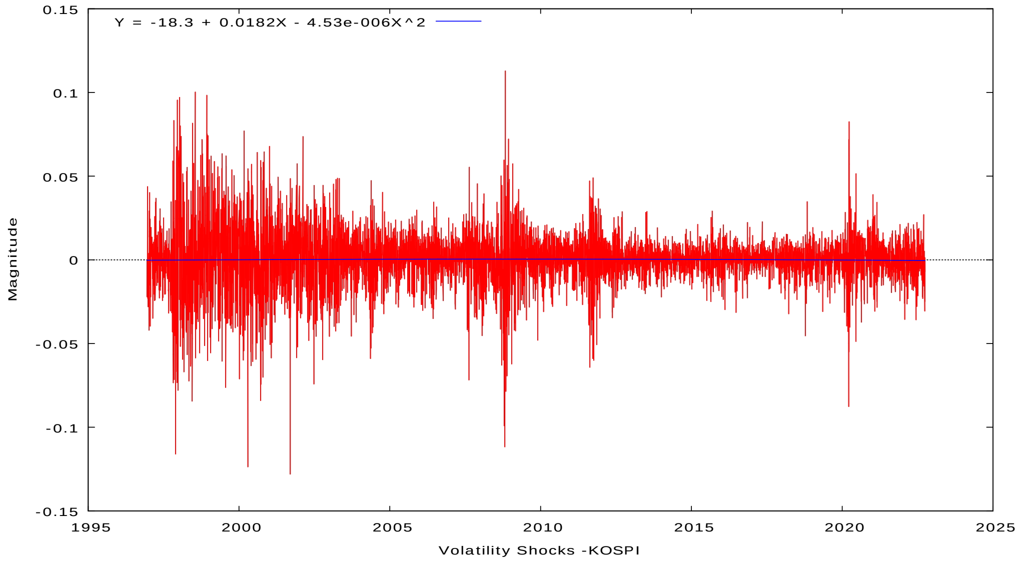


Source: Author's computation using daily closing price returns from 1996 to 2022

Augmented Dickey-Fuller test conducted using from 4 lags, criterion AIC with sample size 6354 where unit-root null hypothesis: a = 1, the primary results indicates test with constant including 4 lags of (1-L)y = b0 + (a-1)*y(-1) + ... + e, estimated value of (a - 1): -1.04562, test statistic: tau_c(1) = -38.0148 and asymptotic p-value 1.159e-027 confirms the series is now stationary. Other normality test statistics also provided significant results at significance level of 1%. (Doornik-Hansen test = 3232.03, with p-value 0, Shapiro-Wilk W = 0.916024, with p-value 1.45838e-050, Lilliefors test = 0.0925097, with p-value ~= 0, and Jarque-Bera test = 9738.51, with p-value 0.

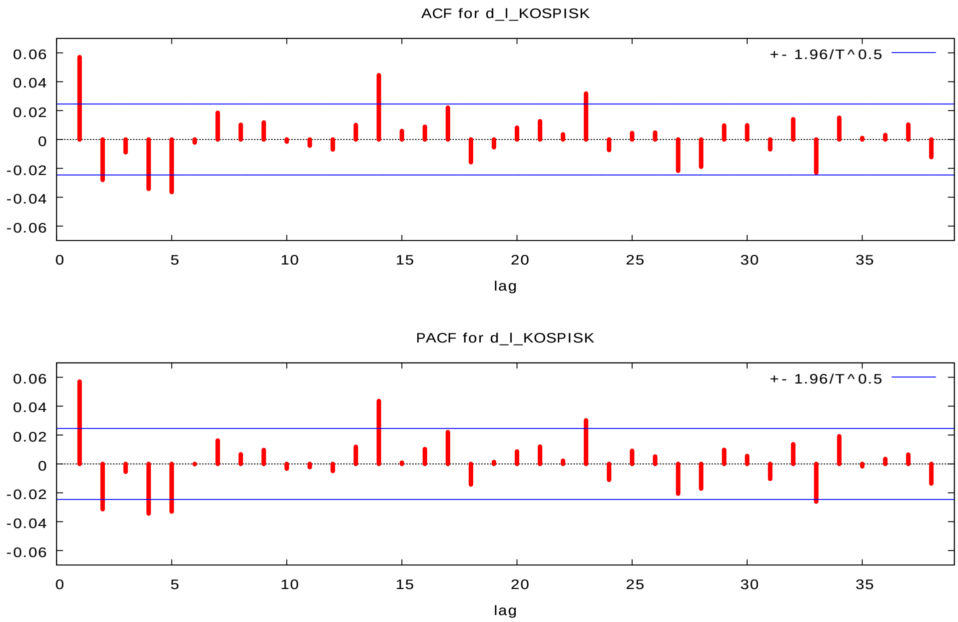
Stationary series returns (Volatility Shocks), ACF and PACF, and left-tail exhibited in Fig – 2, Fig – 3 and Fig – 4 respectively. The ACF of the square standardised residuals and ACF of the square returns are comparable. Numerous economic and financial applications, including as asset pricing, risk management, and portfolio allocation, regard volatility as a key notion. This study aims to compare the effectiveness of several econometric volatility models such as GARCH, EGARCH and GJR.

Figure 2. Stationary series returns – KOSPI (South Korea)



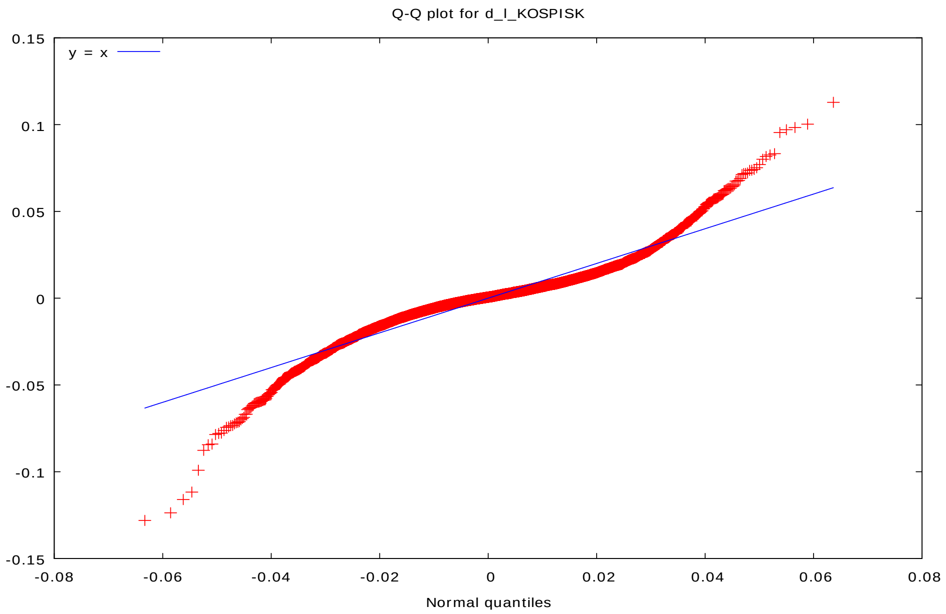
Source: Author's computation using daily closing price returns from 1996 to 2022

Figure 3. Dynamics of ACF and PACF plots



Source: Author's computation using daily closing price returns from 1996 to 2022

Figure 4. Property of Quantile Plot using observation from KOSPI financial index



Source: Author's computation using daily closing price returns from 1996 to 2022

4. Empirical results

Summary of statistics (See Table 1) indicates that that South Korean financial indexed does not follow normal distributions; the kurtosis exceeds normality parameter and creates leptokurtic impact, with negatively skewed returns. The positive mean suggests that exchange returns gradually rise over time. The coefficient of skewness shows that the distribution of returns is asymmetric, or skewed to the left. Returns have a kurtosis of 6.04, which is higher than three and indicates that the distribution of returns follows a fat-tailed distribution. This shows leptokurtosis, one of the key features of financial time series data.

Table 1 Summary Statistics, using the observations 1996-12-11 - 2022-09-30 for the variable d_l_KOSPISK (6359 valid observations)

Mean	Median	Minimum	Maximum
0.00017582	0.00069900	-0.12805	0.11284
Std. Dev.	C.V.	Skewness	Ex. kurtosis
0.016796	95.529	-0.22592	6.0457
5% Perc.	95% Perc.	IQ range	Missing obs.
-0.026583	0.024530	0.014355	1

Source: Author’s computation using daily closing price returns from 1996 to 2022

The GARCH (1, 1) model studies the dynamics of volatility and hypothesises that any shock, whether positive or negative, can cause permanent change in all future values if the product of the coefficients for ARCH and GARCH is equal to 1. If not, conditional variance shock will be classified as persistent in nature. Actual series returns, volatility shocks, and comparative asset returns for KOSPI (South Korean Financial Index) indicates that during COVID-19 pandemic period, like any other financial markets, KOSPI also responded to pandemic events. However, it is interesting to note that the index have recovered rapidly (See Fig – 2).

In this study, the probability focused to evaluate conditional volatility. Asset returns are thought to follow a normal distribution, according to Engle (1982). The normality assumption, however, could significantly distort asymmetric GARCH estimation and understate volatility because asset returns are not normally distributed. Plot of the log returns series (Volatility Shocks) for the KOSPI exchange rates reveals periods of high volatility, sporadic extreme swings, and volatility clustering, whereby upward swings are frequently followed by other upward swings and downward swings are frequently followed by other downward swings. Table 2 shows the results of the fitted GARCH (1, 1), EGARCH (1, 1), and GJR (1, 1) for KOSPI estimated taking into account the initial difference of log return series with normal distribution. The "leverage effect," which is a dynamic asymmetry, and its presence were intended to be captured by asymmetric GARCH models. If the value of is smaller than zero, the "leverage effect" is present.

For the purpose of analysing how the global financial crisis affects stock market volatility, the GJR GARCH model was used. The fact that GARCH models enforce a symmetric volatility response to positive and negative shocks is a significant flaw in their design. It should be observed, nevertheless, that negative shocks are more likely than positive shocks to result in increases in volatility for South Korean stock index (KOSPI) . The asymmetric model parametric confirms presence of leverage effect, suggesting that prices tend to follow negatively movement in more aggressive pattern than the reaction to positive movements. In the years leading up to the financial crisis, the majority of indices' daily mean returns were positive. In the wake of the financial crisis and the pandemic, the daily mean returns for the majority of indexes were impacted. However, the post-pandemic movement indicates strong positive recovery for the South Korean stock index.

Table – 2 Model: Property of GARCH Class models (Normal)*

Conditional mean equation

coefficient	std. error	z	p-value		
const	0.000402468	0.000131882	3.052	0.0023 ***	GARCH (1, 1) [Bollerslev]
const	0.000142386	0.000146910	0.9692	0.3324 -	EGARCH(1,1) [Nelson]
const	0.000176358	0.000130439	1.352	0.1764 -	GJR (1, 1) [Glosten et al.]

Conditional variance equation

	coefficient	std. error	z	p-value	
GARCH (1, 1) [Bollerslev]					
omega	1.14643e-06	3.34439e-07	3.428	0.0006	***
alpha	0.0832349	0.0109077	7.631	2.33e-014	***
beta	0.914859	0.0106061	86.26	0.0000	***
GJR (1, 1) [Glosten et al.]					
omega	1.25581e-06	3.68678e-07	3.406	0.0007	***
alpha	0.0753555	0.0113367	6.647	2.99e-011	***
gamma	0.239612	0.0367753	6.516	7.24e-011	***
beta	0.916221	0.0119379	76.75	0.0000	***
EGARCH(1,1) [Nelson]					
omega	-0.195914	0.0306494	-6.392	1.64e-010	***
alpha	0.160035	0.0177123	9.035	1.64e-019	***
gamma	-0.0522922	0.00892502	-5.859	4.66e-09	***
beta	0.991409	0.00236511	419.2	0.0000	***

Source: Author's computation using daily closing price returns from 1996 to 2022

5. Conclusions

The variance equation's coefficient of the dummy variable for the majority of indices was positive and significant, which suggests that during the most recent financial crisis, spot market volatility in India rose. The outcomes also demonstrated the existence of an asymmetries effect in the volatility of stock returns. This essay's goal is to examine the impact of changes in the stock market's volatility in South Korea. The investigation took into account the daily closing prices of the KOSPI from November 1996 to September 2022. The study shows compelling evidence that the aforementioned models can adequately describe daily returns. According to descriptive statistics, the KOSPI exhibits excess kurtosis and negative skewness. The results of the ADF and JB tests show that both the ARCH effect and the volatility clustering effect are present in the residuals in a significant manner. White noise was found in the standardised residuals and the squared standardised residuals.

Authors' Contributions:

The authors contributed equally to this work.

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