MACROECONOMIC DYNAMICS: UNRAVELING VOLATILITY PATTERNS IN THE PAKISTAN STOCK EXCHANGE USING E-GARCH

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Abstract

This study explores the dynamics of Pakistan's equity market, specifically the PSX 100 index between January 2010 and December 2018. Using the E-GARCH model, it investigates how global and domestic macroeconomic variables affect equity returns volatility. Descriptive statistics highlight key variable characteristics, such as negative skewness and leptokurtosis in PSX returns. Stationary tests confirm the lack of trends, supporting the use of time series modeling. The EGARCH model reveals volatility asymmetries, suggesting that positive shocks result in less volatility than negative shocks. Granger causality tests uncover one-way relationships, indicating the influence of oil, gold, and exchange rates on PSX return volatility. These findings have implications for risk management and decision-making. Future research may explore external factors' impact and assess model robustness across different time frames.

Keywords: Macroeconomics Variables, Volatility of Stock Markets, Equity Returns, E-Garch

INTRODUCTION

Financial markets as the name indicates, are vital to the economy in transferring funds or capital from those who have more resources to individuals or firms who can productively use these funds (Schell et al., 2024). For analyzing the performance of an economy and for modernization of financial regulations and future developments, the role of financial markets are highly effective in this regard. Furthermore, stock market which is an important financial intermediation plays a vital role in developed as well as developing countries. Accordingly, the performance of stock market is measured by the volatility of stock returns. The rapid growth of these markets created a lot of interest in analyzing the volatility of equity markets returns. Under these circumstances volatility of stock returns has been a crucial theme in the study of financial markets. Moreover, Policy makers and market practitioners have taken keen interest in stock market volatility. Policy makers want to determine the volatility spillover effects of economic activity as well as determinants of volatility (Iqbal et al., 2024). Equally important the impact of volatility on the pricing and hedging of options and other exotic derivatives developed a keen interest of market practitioners to determine the effects of volatility. Among such effects, the effect of macroeconomics variable on the volatility of stock returns has intended the academics and equity market professionals and regulators for so many years.

There is a wide range of discussion in finance literature that developed equity market as well as emerging equity market returns are highly effected by macroeconomic news, and financial analysts has deep insight on the economic data release as well as announcements of policy changes, because such changes may affect the volatility of returns and which may cause higher return with least risk or helps in evaluating risk management strategies.(Ross)in his multifactor model shows the evidence that economic variables have direct bearing to the pricing cooperativeness of financial markets (Koch et al., 2024). Thus, financial equity markets are greatly influenced by the systematic economy wide factors and

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(Corradi et al., 2013) documented the impact of macroeconomic variables on equity market volatility of USA, evidence of the study showed that equity market volatility is highly influenced by macroeconomic variables and most of the effects are come from seasonally adjusted industrial production index. Perhaps, the volatility in equity markets is induced by the improbability of country's basic economic variables. It shows that macroeconomic variables play a vital role in the volatility of stock returns.

Thus, the measurement of stock return volatility is linked with several macroeconomic factors and thus captures the performance of equity markets (Ewing, 2002) Identified the degree and determination of unexpected changes in monetary policy, real output, risk and inflation on volatility of equity markets and argue that macroeconomic variables has significant influence on volatility of stock markets returns. One of the macroeconomic factors i.e., inflation has significant effect on stock return volatility. However, magnitude of change in inflation rate is relatively low as compared to inflation rate on explaining the stock market volatility (Murungi, 2012). Further extension was done by (Muriu, 2014), suggesting that money supply and exchange rates are also related to the stock return volatility.

Emerging equity markets recognized high return volatility as compared to developed equity markets as stated by (Imrohoroglu, 1997). It shows that emerging equity markets has attracted the consideration of investors due to its distinguished volatility. In the last two decades there is an evidence of persistent growth of capital markets in emerging markets and these markets are continuously rising even after many financial crises including financial crisis of 2008-2009. One of the most influencing characteristics of equity markets of emerging countries is that it occupies higher volatility as compared to developed equity market (Aggarwal, 1999; Bekaert & Harvey, 1997).

Very few studies related to Asian equity markets are documented (Bilson et al., 2001), (Chowdhury et al., 2006), (Rafique, 2011), (Ray, 2012), (Tangjitprom, 2011), (Hussain, 2012) and (Hussin, 2012) shows the relationship between macroeconomic variables and equity markets volatility of emerging equity markets of Asia(Ibrahim, 2002) determine the lead lag relationship between stock return volatility of equity market of Malaysia and macroeconomic variables and inspect the role of domestic factors (money supply and industrial production) and external factors (exchange reserves and exchange rates) respectively (Naik, 2013) investigate the relationship between the volatility of Indian equity market return and macroeconomic variables i.e., Industrial production index, whole sale price index, money supply, treasury bills rates and exchange rates(Attiya, 2018) studied the impact of volatility of macroeconomic variables (market return, industrial production, inter-bank call money rate, term structure of interest rate, money supply, exchange rate and inflation rate) on conditional volatility of stock return for fifty stock listed at KSE using Hendry's general to specific strategy with Zellner's iterative procedure. We precede this research with new conceptual frame work. The ultimate purpose of this research is to investigate the impact of macroeconomic variable volatility on the equity market returns of Pakistan market respectively (Zubair et al. 2014).

The key objective of the study is to examine the impact of macroeconomic variables on volatility of equity returns of PSX 100 index for the time period of January 2010 to December 2018 respectively-GARCH model is applied to determine the impact of volatility of macroeconomic variables on volatility of stock returns. In the meanwhile, the macro-economic variables included in the study are Exchange rates, oil prices and gold prices respectively. The study is further cleft into four sections. Previous empirical work is discussed in section two. Whereas, section three discusses the data and methodology and finally the last section explains the data analysis, empirical results and conclusion respectively.

The interests of both investors and policymakers lie in recognizing the factors affecting the pricing of a stock. Valuation models, which indicate the cash flows of stocks and required rates of return,

where the return represents the cash flow riskiness, determine the prices of stocks (Ross, 1986). These considered effects have been studied extensively. Ross (1986) considered the effect of systematic economic variables on future dividends and discount rates, inferring that stock returns are determined by permanent factors in the economy which ensure a long-run equalizing relation between stock prices and macroeconomic variables. Also, Chen et al. (1986) developed a multifactor model to measure the contribution of macroeconomic volatility on stock returns in the USA. The researchers observed that variables as industrial production, changes in risk premiums, and the dynamics of yield curve all systematically affect stock market returns, moreover these variables affect the expected of stock return. Simultaneously, variables including stock market indices and per capita income failed to influence asset price, which rendered no significance.

We will further it by bringing Chen (1991) into focus and his discussion on the correlation between macroeconomic variables and shifts in financial investment opportunities in the U.S market. Their paper substantiated several macroeconomic lagging variables, such as the production growth rate with a lag of one quarter, default and term premiums, and interest rates in the short run, as being strong predictors for the future market growth, thus confirming positive linkage between the examined variables (Hussain et al., 2009). When they move outside the USA market, Clare and Thomas (1994), examine the role of macroeconomic factors on UK equity market returns. After examining eighteen macroeconomic factors, they identified retail price indices, oil prices, bank lending, and corporate debt as crucial risk variants which influence equity returns in the UK.

In Japan, the work of Mukherjee and Naka (1995) was based on Johansen's vector error correction model to contemplate the association between Tokyo equity market and macroeconomic variables of Japan. The findings that reported on these stock prices and variables such as the exchange rates, total money supply, and industrial production co-integration relations weighed on the phenomenon that stock prices are an important part of these relations. In line with that, Bilson et al. (2001) sought to imply the relevance of regional and global macroeconomic variables on the emerging equity markets. The article may be noted as an analysis of the importance of global factors in their respective markets with a consideration of weighted world market index and exchange rates. It also puts light on the fact that local economic policy is of no less significance compared to that foreign policy.

In the context of Africa; in their research article titled: "Volatility in the Nigerian equity market in response to inflation and exchange rate variability" (Nkoro & Uko, 2010). Their study uncovered a strong correlation of these macroeconomic modifications and stock market volatility where the market gets exposed to economic changes making it sensitive to the changes. For instance, just like Ouma and Muriu (2014) studied the role of macroeconomic variables on Kenya stock market volatility. Their work showed that volatility of market prices literally stood and fell at the shortest pace save for the money supply and inflation, which served to emphasize the role of monetary policy in defining market forces.

Pinjaman and Aralas (2015) in Southeast-Asia examined how macroeconomic variables effect on stock returns across different industries in Aki Malaysia. The initial results showed that not only economic shocks but also macroeconomic interconnectedness are a decisive factor influencing stock market volatility. A study of Wongbangpo and Sharma (2002) of how the stock's price responded to macroeconomic factors of five Asian countries was conducted. They showed the spectrum of the resulting effects of macroeconomic variables on stock prices due to the differences in time perspectives. This shows the relationship between macroeconomic and stock price market, which keeps changing all the time.

They have proved experimentally that some class of variables as the macroeconomic variables

can, to a great extent, stimulate the volatility of the stock market. On the other hand, the task remains to reconcile the obviously divergent tendencies of major economic of variables and stock market return volatility. Little work has been done so far using low-frequency indicators of macroeconomic variables as data inputs for the deep learning models. Song et al. (2023) approached this deficit by proposing a hybrid model which incorporates machine learning techniques and GARCH mixed data sampling by using the generalized autoregressive conditional heteroskedasticity known as GARCH-MIDAS so as to forecast stock market volatility. By including the macroeconomic variables in their model, they have found that it leads to an improvement of forecasting accuracy by a substantial margin. Being inspired by Khan et al. (2023) findings, the authors also explored the influence of oil prices, gold prices, and exchange rates on stock return in the Shanghai exchange. Through their dynamic ARDL model simulation, they analyzed monthly level data over the time span of 18 years moving from January 2000 to December 2018. It appears that oil prices, gold prices and global stock returns tend to move in the same direction over a long-term and short-term horizon, where finally the change of exchange rates to affect the stock prices negatively over both these periods. Consequently, this can mean a lot for policy makers in terms of identifying the interdependency of the macroeconomic crimeters as well as stock market growth. In the next line, the other study by Mugendi (2024) evaluated the influence of the macroeconomic indices on stock market volatility in Kenya. Mugendi implemented the desk methodology which entailed a thorough review of existing literature and reports prior to assemblage. Consequently, he managed to carry out consultations seeking alternative information sources. The results supported the notion that variants of inflation rate, change rate of exchange, and the interest rate affected stock market volatility indexes of Kenya. Moreover, alongside those factors like GDP growth and oil price fluctuations which exhibited associated boosting or suppressing to stock market volatility? This research highlights that besides the microeconomic factors, the attempts to understand the stock market dynamics must enclose the study of the macroeconomic factors on which the decision makers will base their policies informing the investors to make informed investment decisions.

As a whole, these researches help us in putting together the sophisticated linkage between macroeconomic factors and stock market fluctuations. The use of sophisticated modeling tools as well as the processing of real-world data has greatly contributed to a better understanding of the mechanisms behind financial markets that can inform investment strategies and policymaking.

RESEARCH METHODOLOGY

The study examines the relationship between macroeconomic variables and equity returns of Pakistan equity market. Time series analyses are employed for determining the impact of macroeconomic variables on the volatility of equity returns of Pakistan equity market. Theoretical literature on time series analysis showed that it consists of numerous shocks and instability; thus there is an existence of heteroscedasticity in the cross sectional data. Thus, the variance of disturbance term is less stable in such analysis. For this purpose, UNIT ROOT test is done to check the stationary in the data.

Unit Root Test

While seized into deliberation the time series analysis, checking the stationary of data is very important aspect before applying the model or moving towards further estimations. It happens most of the time that the data is non-stationary and to convert that data into stationary data several econometric techniques are used. There are many techniques that are used to check that problem but the most popular technique is Augmented Dickey Fuller (ADF) test is mostly used in this regard. As (ADF) test has special feature that

it removes serial correlation due to the availability of extra lags for the dependent variables of the model. The ADF can be written as:

$$\Delta Y_t = \Phi_o + \Phi_1 Y_{t-1} + \sum_{i=1}^{p} \Psi_1 \Delta Y_{t-1} + \mu_t$$

In the above equation Y is the variable in the particular time ***t,*** and ***t – 1***shows the lag periods.

Exponential Generalized Auto Regressive Conditional Heteroscedasticity (EGARCH)

While taken into consideration the concept of volatility persistence the ARCH model is used to capture the phenomenon of changing in variance and volatility. It is also used to to determine the phase of increasing volatility. For many financial theories and their estimations ARCH models provide applicable framework for determining volatility but, in case of many parameters the model is not useful and there exists chance of volition of non-negativity constraint in the coefficient of conditional variance. To overcome such problems further extensions in the models took place. Thus, further extension in ARCH is done by **(**Bollerslev, 1986) introducing GARCH (*p, q*). Here Conditional variance depends on *q* lags of the squared error and *p* lags of the conditional variance, is the general case of the model is known as GARCH (*p, q*).

The benefit of GARCH model is that it takes small number of terms and shows better results than ARCH higher model, while determining the volatility situation in different growth aspects, it is assumed that falling growth periods have high volatility in spite of high growth stages where the volatility is surely low. Consequently, neither ARCH nor GARCH model is helpful for capturing the asymmetric data. Wherefore, for the detention of asymmetry in the volatility with a reference to the direction of real growth, a model was developed by Nelson (1991) namely Exponential Generalized Auto Regressive Conditional Heteroscedasticity (EGARCH) model. The EGARCH (1, 1) can be written as:

$$ln\sigma_{j,t}^2 = \omega_j + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\alpha_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\alpha_{t-1}^2}} + \beta_j \, ln \, ln \left(\sigma_{j,t-1}^2 \right)$$

In the above equation $\sigma_{j,t}^2$ showsthe conditional variance, it shows one period ahead estimates for the variance, which is calculated on any past information. However,$\omega_j, \beta_j, \gamma$ and α are the parameters of the equation to be estimated. One of the most significant advantages of EGARCH model is that it has $ln\sigma_{j,t}^2$ in the model and it certainly makes the parameters positive, if there is an existence of negativity in the parameters.

The β in the equation measures the volatility spillover or volatility persistence in the conditional variance, regardless of any circumstances or changes in the market. In the mean while α in the model represents the GARCH effect; showing the magnitude of symmetric of the model. Furthermore the EGARCH model allows the testing of asymmetries in the data and for this estimation the parameter γ is used to measure the asymmetry or leverage effect in the data. There are three different degrees of this parameter and each degree indicates the situation of asymmetries in the data. If $\gamma = 0,$ then model is symmetric. When$\gamma < 0$**,** means that positive shocks generate less volatility than negative shocks or negative shocks marked more impact than the positive shocks. When $\gamma > 0$then the case is opposite, showing that positive shocks inaugurate more volatility as compared to the negative shocks.

Granger Causality Test

To determine the causes and effect relationship among macroeconomic variables and stock variables,

Engle – Granger causality test is used to observe the phenomenon. In this test, the causality of one variable (Y) to another variable (X) is determined. Perhaps, X is said to be granger cause due to Y and in the mean while the degree of accuracy can also be captured by taken into deliberation the previous values of X. It can be written as follows:

$$Y_t = \delta_0 + \alpha_1 y_{t-1} + \beta_1 x_{t-1} + \mu_t$$

In the above equation α_1 and β_1 are the parameters of the equation. In the equation, if$\beta_1 = 0$, in this case the variable X does not granger causesY. Accordingly, if the value of the coefficient β_1 is non-zero, it simply means that X does granger cause Y. The granger causality test also captures the direction of the granger in the three different ways: Uni-directional, bi-directional and non-directional causality.

Data and Variables

To determine the effect of macroeconomic variables on the equity returns of Pakistan, the stock market index of PSX (100 index) represent the equity market of Pakistan. There are several macroeconomic variables that affect the equity return and stock market conditions; Nominal Exchange rate, Gold prices and oil prices are the macroeconomic variables that are taken into the study. While determining the volatility of equity returns of Pakistan stock market, Weekly time series data is used to analyze the influence of macroeconomic variables. The weekly data of the variables covers the time period of 1stJanuary 2010 to 31stDecember 2018 respectively. The data of these macroeconomic variables are collected from International financial Statistics (IFS), Federal Bureau of Statistics, and Bulletins of State Bank of Pakistan. The data of stock index is collected from Official website of Pakistan stock exchanges. While for determining the returns of PSX 100 index and macroeconomic variables, percentage daily log return for particular indices are used by taking the first difference of the log indices and multiply them by 100, i.e. $\mathbf{Rt=(lnPt-lnPt-1)\times 100}$.

The effects of macroeconomic variables on the equity return of Pakistan equity market is performed in three different steps. Firstly, the stationary of the data is checked by applying ADF test. Secondly, EGARCH model is applied to check the volatility of each variable in a Univariate analysis. Finally, Granger causality test is used to determine the causal relationship among the variables of the study.

EMPIRICAL RESULTS

This section provides the detailed results of various econometrics tools that are used to determine the effects of macroeconomic variables on the equity returns. Table 01 shows the descriptive statistics of the data; Table 02 shows the results of ADF test; however, Table 3 shows the results of EGARCH model along with the diagnosis of the model. Finally, the results of Granger causality test among the variables are captured in the Table 04.

Descriptive Statistics

Table 1 provides the results of descriptive statistics including mean, median, standard deviation, Skewness, Kurtosis, Jarque – Bera and probability of the percentage daily log returns of PSX 100 index and other macroeconomic variables; Gold price, oil prices and exchange rate respectively.

Table 1
Descriptive Statistics

CONTENTS	PSX RETURN	GOLD	OIL	EXCHANGE RATE
MEAN	0.003474	1309.537	73.03390	98.46192
MEDIAN	0.004809	1276.800	73.78000	100.5500
MAXIMUM	0.097654	1873.700	113.9300	139.9000
MINIMUM	-0.111667	839.3000	29.42000	79.05000
STD.DEVIATION	0.024490	207.8607	21.92638	11.84864
SKEWNESS	-0.411404	0.508900	-0.054949	0.663136
KURTOSIS	5.495033	2.982417	1.679781	3.900417
JARQUE – BERA	149.8353	22.49478	38.09932	55.78495
PROBABILITY	0.000000	0.000013	0.000000	0.000000
OBSERVATIONS	521	521	521	521

The average weekly return on stock is 0.34%, weekly average gold price is 1309.537 USD/1 Troy Ounce, and weekly average exchange rate is Rs. 98.46/ 1 USD and weekly average oil prices are 73.033 USD/Barrel. The standard deviation of the return series, gold price, oil price and exchange rate are 0.0244, 207.86, 21.926, and 11.84 respectively. Thus, macroeconomic variables show high deviation in their prices. The stock returns show negative Skewness in their market returns showing the existence those large positive returns are not common in these markets as compared to negative returns. However, the gold and exchange rate show positive Skewness and oil prices show negative Skewness. While analyzing the Kurtosis result in the table 1 show that the distribution of PSX return is more leptokurtic than those of Gold, oil and exchange rate prices respectively. The Jarque – Bera value is high in PSX return as compared to gold, oil and exchange rate prices at 5% significance P-value.

Stationary Test

There are several tests which are conducted to test the presence of unit root in the series. This study focuses on ADF test presented by Dickey and Fuller. While testing the ADF test, the notion shows that the series has unit root, is the null hypothesis. However, unit root is performed with only one specification i.e. with intercept but no trend in the mean equation. The results of ADF test shows the existence of unit root in all the series of variables and stationary exist in all the series of returns. Thus, all series are stationary and possess no trend. All the results are significant showing that all shocks are eliminated and now in the position to apply time series models for accurate decisions for the future prediction. The results of the ADF test are reported in the Table 2 below.

Table 2
ADF Unit Root Test

VARIABLES	T – STATISTICS	P – VALUE
PSX RETURN	-20.39847	0.0000
OIL	-21.88422	0.0000
GOLD	-22.57167	0.0000
EXCHANGE RATE	-4.186532	0.0008

Critical values of ADF test at intercept but no trend.
1% level = -3.442698
5% level = -2.866879

Volatility Estimation Using EGARCH

Table3
PSX 100 index and Macroeconomic Variables – EGARCH (1,1)

Variable	Coefficient	Std. Error	z-Statistics	Prob.
C	0.003912	0.000984	3.973705	0.0001
Gold Return	-0.037847	0.038548	-0.981822	0.3262
Oil Return	0.042464	0.019639	2.162168	0.0306
USD Return	-0.246195	0.122909	-2.003063	0.0452
VARIANCE EQUATION				
ω	-0.919805	0.194866	-4.720197	0.0000
α	0.211990	0.053865	3.935603	0.0001
γ	-0.076916	0.028167	-2.730712	0.0063
β	0.901080	0.023578	38.21771	0.0000

The β in the equation measures the volatility spillover or volatility persistence in the conditional variance, regardless of any circumstances or changes in the market. In the mean while αin the model represents the GARCH effect; showing the magnitude of symmetric of the model. Furthermore, the EGARCH model allows the testing of asymmetries in the data and for this estimation the parameter $\gamma$is used to measure the asymmetry or leverage effect in the data. There are three different degrees of this parameter and each degree indicates the situation of asymmetries in the data. If $\gamma = 0$, then model is symmetric.When$\gamma < 0$, means that positive shocks generate less volatility than negative shocks or negative shocks marked more impact than the positive shocks. When $\gamma > 0$then the case is opposite, showing that positive shocks inaugurate more volatility as compared to the negative shocks.

According to the results we can find that the leverage effects are positive the coefficient $\gamma$is almost negative and it is also significant and thus shows that good news generate less volatility as compared to bad news for Pakistan equity market.

Granger Causality Test

For determining the causality relations among the variables Granger causality test is used. The outcomes of the results indicate that there is an existence of Uni-directional relationship between Oil return volatility to PSX return volatility. The rejection of Null hypothesis occurs at 5% significant level shows that oil return volatility does not granger causes PSX return volatility at significant P – value. In case of gold return volatility, the case is different, it shows the existence of Uni-directional relation but here PSX return volatility granger cause to the gold return volatility. Thus, the rejection of Null hypothesis occurs at 5% significant level shows that PSX return volatility does not granger cause gold return volatility at significant P – value. The case of exchange rate is similar to gold return volatility, here PSX return volatility does granger cause the volatility of exchange rate return and shows the presence of Uni-directional relation of PSX return volatility to exchange rate volatility. Thus the rejection of Null hypothesis occurs at 5% significant level shows that PSX return volatility does not granger cause exchange rate return volatility at significant P – value.

Table 4
Granger Causality Test

Null Hypothesis	F – Statistics	P – value
Oil Return volatility does not Granger Cause PSX return volatility	7.41700	0.0007
PSX Return volatility does not Granger Cause oil return volatility	0.24962	0.7792
Gold Return volatility does not Granger Cause PSX return volatility	1.23132	0.2928
PSX Return volatility does not Granger Cause gold return volatility	3.33124	0.0365
Exchange rate Return volatility does not Granger Cause PSX return volatility	0.78682	0.4558
PSX Return volatility does not Granger Cause exchange rate return volatility	3.76387	0.0238

CONCLUSION

In conclusion, this research thoroughly examined the influence of global and domestic macroeconomic variables on Pakistan's equity market volatility, specifically concentrating on the PSX 100 index from January 2010 to December 2018. The descriptive statistics unveiled distinctive features in the PSX return, gold prices, oil prices, and exchange rates, highlighting negative skewness in PSX returns and positive skewness in gold and exchange rates. The leptokurtic nature of PSX returns indicated by higher kurtosis and the Jarque–Bera statistic revealed significant deviations from normality. The Augmented Dickey-Fuller (ADF) unit root tests provided evidence of stationary behavior in all series, eliminating trends and establishing a robust foundation for time series models. The application of the EGARCH (1,1) model elucidated crucial insights into volatility dynamics, emphasizing the impact of macroeconomic variables on equity returns volatility. Notably, the observed leverage effects suggested that positive shocks generate less volatility than negative shocks, offering nuanced insights into market reactions.

The Granger causality test uncovered unidirectional relationships, with oil return volatility influencing PSX return volatility. The implications of these findings are substantial for investors, policymakers, and market participants, providing valuable insights for risk management and decision-making. The observed asymmetry in volatility responses underscores the importance of considering both positive and negative news in forecasting market dynamics.

Implications

These findings have significant implications for investors, policymakers, and market participants. Understanding the directional relationships and volatility spillover do affect the aid in risk management and decision-making process. The observed asymmetry in volatility responses to positive and negative shocks emphasizes the importance of considering both positive and negative news in forecasting market dynamics.

Future Research Directions

Looking ahead, potential research directions involve exploring the impact of geopolitical events, market sentiment, and regulatory changes on equity market volatility to enhance our understanding. Additionally, assessing the robustness of results over different time periods and incorporating machine learning models for prediction could further contribute to the research landscape.

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