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SPILLOVER AND VOLATILITY IN BRICS NATIONS DURING PANDEMIC: EVIDENCE FROM GARCH MODELS

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ABSTRACT: The financial markets of a country are considered the barometer of the performance of an economy. The government of the country plays a major role in promoting and stabilizing the performance of its stock markets. However certain unprecedented events create disruptions in the smooth functioning of the system. COVID-19 was such a disruption that had a huge repercussion on the varied countries of the world. This study seeks to understand the impact of volatility caused in BRICS nations due to COVID-19 using GARCH and EGARCH Models. The findings show that high level of volatility and fluctuation in returns is found to be highly persistent in all five indices. The asymmetries in volatility and leverage effect have been observed in all the indices. The findings of this paper will benefit people and investors who manages portfolio and policymakers in making valuable decisions regarding the allocation of funds to portfolios, managing the risk, and also in the formulation of monetary policies.

KEYWORDS: COVID, BRICS, VOLATILITY, SPILLOVER EFFECT, GARCH, EGARCH

1 INTRODUCTION

Volatility is the fluctuation caused due to uncertainty in the market which enhances the insecurity and intensity of risk among investors. One of the prominent reasons responsible for this uncertainty is the spillover effects of anonymous events. In economics, we study the cause-and-effect relationship, for any event, there is a definite cause behind it that has occurred in the past or is occurring at present. This impact may have positive or negative outcomes. Spillover means something that spreads or has some unexpected outcomes. In finance, we see *spillover effect as the effect or series of effects on one economy due to the event that occurred in some other economy*. Again these jolts can be positive as well as negative. Conventionally spillover effects have negative repercussions on the economy. For instance, we have recently seen the whole world suffering due to the novel coronavirus

originating in the Chinese city of Wuhan. The lives of people all over the world have been affected due to this disease. Be it the economic power of the US or any other developed country, none of them could abide by the hard-hitting impacts caused due to this pandemic. It is not only on the health front, but the repercussions were visible on the financial and economic levels too. Countries are still struggling to overcome this impact and will continue doing so for a longer period. Another example of the spillover effect can be in the form of crises in Afghanistan. In August 2021 Taliban took over control of Afghanistan, which has created a plethora of uncertainty and tension not only among the local nationals but also among the neighbouring nations. India has invested approx. $ 3 billion in infrastructure projects in Afghanistan which seems to be in peril due to unreliability over the rule of the Taliban. This event in our neighbouring country will certainly have a spillover effect on the economy of India.

1.1 Spillover Effect in Capital Market

The huge infusion of funds in stock markets in the 1900s was accompanied by a surge in the volume of transnational currency and security negotiations. Moreover, as a result of financial globalization, global markets now exist on a worldwide scale, where assets may be transacted in real-time and without restrictions in any region of the world (Gulzar et al., 2019). The stock exchanges throughout the world are connected in some capacity, even if they aren't completely connected. They do, however, have rub-off effects and can sometimes result in a market-wide contagion effect. The majority of the world economies are interdependent. Because the United States is the world's largest economy, most other economies rely on it in some way. They either export or import from the United States. As well as the US dollar is the most widely used currency in the world, it has a significant impact on global markets. The dollar's swings have a significant impact on other markets. One major event that occurred after the great depression of the 1930s was the fall of the financial sector of the US in 2007-2009. Soon it took the shape of global financial crises and proliferated to almost all emerging and advanced economies as well. Not to mention, it affected major equity markets and these emerging economies had to endure the excruciating reactions in their capital and equity markets. Since then spillover effect has been contemplated as an important subject matter that cannot be ignored. When a noted event in a country has a wavelet effect on some other country's economy it is considered as a spillover effect. Moreover, the affected economy in one or another way is associated with the country in which the event has occurred. In other

words, the effects of globalization, international commerce, and interconnected financial markets amongst different economies are referred to as the spillover effect.

1.2 Pandemic Effect on Spillover Effect

Public health crises can have an impact on the economy because investor expectations and confidence in the future of the economy have an impact on the stock market. (Youssef et al., 2021). Events that transpire in an economy have an unswerving impact on the performance of the stock markets not only in that respective country but also in other interconnected countries. For instance, an outbreak of COVID-19 in China had severe spillover effects on the global economy which prompted the recession at the global level. Global pandemic regulatory lockdowns have had a major impact on both the real estate and financial industries. Furthermore, stock markets seem to be more sensitive to this pandemic than the real (Hasan et al., 2021). A continuous prevalence of shock transmission led to huge volatility co-movement in India. Increasing COVID-19 cases created a cash-flow crunch in emerging economies. There has been a rise in volatility spillovers as an impact of the corona Pandemic (Guru & Das, 2021). The unanticipated economic disturbance created by pandemic is not only catastrophic but also has spillover effects as the economic activities have been baffled in almost all locale of human venture. According to S&P Dow Jones Indices, for six days on February 23-28 (Ozili & Arun, 2020). Moreover, the Spillover effect of corona was predominantly evident in the global economic power of the US too. Financial stability in US markets had a major setback due to the health crises aroused because of corona. The oil prices in the US became negative due to the lockdown policies adopted as a measure to narrow down the impact of corona (Shehzad et al., 2021). It is observed that the total risks and the individualistic risks of all industries have increased significantly, while the changes in market risks or volatility vary from one industry to another(Baek et al., 2020). Undoubtedly, this has affected all kinds of business activities mainly the smaller ones. Likewise, the Chinese economy has also seen a significant spillover effect due to this pandemic. Energy business in China is one of the major sector for the growth and development of the Chinese economy so undoubtedly the government is focusing more on its growth. It was quite evident that the imports of energy products were quite high in comparison to the exports in the country and thus most of the requirements for energy products were reliant on the imports. The pandemic has had a wide-ranging impact on the energy industry (Si et al., 2021).

Moreover, corona had a leverage effect in both the US and Chinese stock markets. The effect of corona on market volatility was more when the markets were highly volatile (Gao et al., 2021). There has been increased volatility in Indian stock markets too. Stock prices have seen a lot of fluctuation and with the negative mean returns, stock markets feature losses when pandemic takes place in comparison to the pre-COVID period when returns were positive(Bora & Basistha, n.d.).

2. Literature Review

A number of related studies has been published on the Spillover effect of COVID 19 on stock markets. In an analysis of Spillovers and BRICS economies' financial integration within a VAR-BEKK framework, it has been concluded that investors can diversify their portfolios by investing in gold and oil. Within the BRICS economies, South Africa seems to be the preferred choice for investors (Panda, 2019).

(Bhar & Nikolova, 2007) concludes that rather than world trends, regional trends have more influence on BRIC nations. The variance of return on Brazil, Russia, and India is significantly influenced by the returns of the US market relative to the returns of various world indexes. As per the study, China remains unaffected either on a regional or global basis. Another similar study conducted on BRICS nations Cboe A real-time index is the Volatility Index that indicates the expected market volatility for the coming days and is used by investors to gauge the risk level, fear, and stress existing in the market. (Sharma et al., 2020) use VIX to study Information Linkages among BRICS Countries. A long-run equilibrium relationship between different BRICS countries already exists as is described in findings. Also, there exists a varied degree of connectedness of BRICS as shown in the return and volatility spillover matrix.

(Malepati, 2016) in their study on fluctuation in Indian capital market, states that the intraday returns and volatility in Sensex varied to a higher degree during the study period. The variability in return was over time and space making fluctuations quite evident.

Interestingly, one of the studies conducted to study the Spillover effect of variations in oil prices on Indian stock markets reflects that in more time, global prices had no spillover effect during the study period. Volatility does exist but only for a shorter term and does not have a

long-lasting impact. There is not much effect of global prices on the S&P oil and gas index (Jacob, 2016).

Markets seem to be very volatile when the trade policy is uncertain. Asymmetric spillovers among the considered exchange rates were evident during the study period. Patterns originating during uncertain trade policy can be used to ascertain currency market volatility and how the currency markets at the global level behave (Huynh et al., 2020).

A study states that as soon as there was the formal announcement of COVID-19 news a noticeable and continued impact on Chinese financial markets was evident. There was a directional spillover on bitcoin markets also. Government-developed education initiatives appear to have sparked cryptocurrency-based confidence, which is resilient despite both data frequency and procedure wise variation (Corbet et al., 2021).

There is negative correlation between the government lockdown and the returns generated by stock markets during the same period of time(Alexakis et al., 2021).

There are a number of economic factors and also the pandemic spillover effects are responsible for the huge level of fluctuation in the indices of the capital markets. Both positive and negative sides are there for the coronavirus pandemic, some sectors could see a positive movement and some have seen a negative movement but overall there is more of negative side to corona than positive. Total and distinguishing risk across different sectors increased even if the systematic risk varies from industry to industry (Baek et al., 2020).

Impact of volatility spill lover is for longer term in comparison the impact on the returns. According to the moving window research, COVID-19's impact created an unprecedented hazard, such as declining oil prices and four instances of setting off the circuit breaker on the US stock market, which resulted in substantial losses for investors quickly.

Additionally, corona has influenced oil and stock market volatility more than the 2008 crisis. The level of impact caused due to corona is diversified and more spread. The level of impact kept on varying and cannot be easily predicted (Zhang & Hamori, 2021).

(Ashraf, 2020) The analysis found that as the number confirmed cases during pandemic increased, markets displayed a declining tendency(Liu et al., 2020) and (Khan et al., 2020) utilized econometric models to assess the coronavirus epidemic's short-term impact on major affected countries' stock market indices. With the initiation of this pandemic markets also

started reacting in an inverse direction. For the initial period of study, there was a negative, and later for the second period of analysis, there was a positive relation between pandemic and S&P500 index daily returns. There was a differentiated effect of pandemic on various sectors. Certain utility sectors and sectors appeared to have a positive relation with coronavirus cases because in the uncertain corona-related times, household spending priorities shifted toward fundamental requirements. Major utility sectors were having a positive relation and the sales and revenue of the companies in these sectors was positively getting better and better. The auto industry was among those that suffered the most(Elhini & Hammam, 2021).

(Cheung et al., 2010) a study suggest that assert that the current crisis strengthened the short-term causal relation and the long-term co-integrating even relationship between the US and other international markets.

In an interesting study by (Shehzad et al., 2021) to see the spillover of global economic crises in the financial stability of the US it has been concluded that economic crises in Asian and African nations have hazardous effects on the financial stability of the US economy. Apart from the effects of economic and health crises in the US itself on their financial stability, there were short-run spillover effects of the health crises in Spain and Italy.

A study found that return spillovers are exclusively unidirectional from the Chinese stock market to the US stock market. Although the stock market in the United States consistently has a positive spillover into China's morning trading the following day, it appears to have little effect on China's afternoon trading. The study also suggests that half-day trading on the Chinese stock market is affected by information from the US stock market. In addition, that return spillovers are exclusively unidirectional between these two markets. (Chen et al., 2021).

According to (Aggarwal et al., 1999), The variations in variance vary by nation. They also depend on how often the data are collected: Daily returns yield more change points than weekly or monthly returns. There is a significant overlap between periods of high dollar-adjusted return volatility and periods of high local return variance.

(Natarajan et al., 2014) conclude that there is an impact of news arising in one country over another but up to a certain limit. The dissemination of fluctuations across Australia, Brazil, Germany, Hong Kong, and the United States got investigated, and it was discovered that

looking at volatility interdependence can reveal useful information about how information is transferred across markets. Future prices are also influenced by the past news in some other countries. Expected returns are correlated with conditional market volatility.

(Das, 2021) in her analysis on the Time-Frequency Relationship among Oil Prices, Stock Returns, and currency rate, concluded that there is a strong similar kind of movement in India between a. capital markets and b. forex rates and oil prices. Certain macroeconomic events are the link that binds these two relationships together. According the findings of the author economic disturbance in developed economies may have a spillover on Indian markets performance also.

A sector-by-sector analysis of the spillover effect reveals that there is a transfer of volatility spillover for a short period of time from oil market to the automobile sector because of the direct relationship among the industries. Automobile industry makes use of oil as raw material and thus has a significant role to play in the volatility due to oil price fluctuations. a positive return spillover from oil prices to metal, and a negative return spillover from oil prices to the auto industry.

According to D. Kumar & Maheswaran (2013), the crude oil market has a long-run volatility spillover effect on the services, metal, and mining sectors, while the crude oil market has a negative long-run impact on the automotive finance and energy sectors.

Bhatia (2020), analyzing spillover effects in the financial year cycle for Indian markets, finds that the maximum and minimum mean annual returns occur in February and October. April, May, and October experienced negative average returns. The closing month of the financial year had positive returns and the opening month of April had negative returns.

(Chai et al., 2020) categorized the G20 stock markets into three groups based on their volatility similarities. Each group's stock market co-movements have spillover effects, and the dominating source can be recognized.

The RMB exchange and two stock market indicators are getting correlated because of the impact of trade war as per the results indicated in the study. The transfer of information from the capital market over the fluctuation coming in RMB exchange rate is significantly reinforced(Wu et al., 2020).

The U.S. market and emerging stock markets have a long-term co-integration that has grown since the crisis. Shocks and volatility from the past have a greater impact on specific stock markets at all times. Only the BSE sensex and the Korean Composite Stock Price Index experienced news which is spread across the markets and variation spillover repercussions during the crisis (Gulzar et al., 2019).

The local capital market index and several other global capital markets are highly interdependent. Between India, China, and South Africa, there is now a both way variation spillover between the stock market and the forex markets. Both are having an significant impact over each other (Singh et al., 2021).

Fluctuations are observed and volatility is transferred from stock market of the country to currency exchange markets. The research indicates that there is no evidence of volatility transmission between Japan's two markets. (Jebran & Iqbal, 2016).

3. Methodology

3.1 Objectives

Investigating the rationale for the Spillover effects of pandemic & volatility in different capital markets based in varied economies is facile through contemplating a series of research papers. Our study provides an understanding of the contagion repercussion of the variation of stock prices in the capital markets. Immense fluctuations in the Capital markets are driven by the investors' expectations and behavior which is responsible for the variability in stock prices. However, the returns on these stocks depend on the proficiency of investors to take risks. Moreover, Volatility is navigated by the information flow due to macroeconomic events occurring in domestic or foreign markets which are responsible for instigating the Spillover effects on other economies too.

The current investigation is based on daily stock index observations from five emerging markets: BOVESPA in Brazil, MOEX in Russia, BSE Sensex in India, Shanghai Composite Index in China, and FTSE/JSE (South Africa). The information on Brazil, China, SA, Russia, and India's closing prices is sourced from the financial database on investing.com.

Data has been collected from Jan 2020 to Jun 2022.

For the application of statistical methods, log returns of the complete data are used.

$$Rt = \log(\frac{pt}{pt-1}) \times 100$$

Where, the log is the natural logarithm, pt and pt-1 there the closing prices at period (t) and (t-1) independently.

3.2 Volatility Modelling

Quite a few models with many variations have been introduced since the ARCH and GARCH models were first given by Engle (1982) and Bollerslev (1986). Symmetric and asymmetric models are the two basic categories into which the existing models can be categorized. Symmetric models feature that Conditional variance is only influenced by the size of the underlying asset, not its sign. This feature rarely matches actual findings, which frequently show a leverage effect, whereby volatility rises greater after negative return shocks than after positive return shocks of equal magnitude. In any other case, negative news causes more volatility than good news.

4. Results and Discussion

The findings of the indices data of the BRICS were covered in this part. Table 1 displays five-time series plots representing the closing prices of these markets that were taken into consideration for this investigation. It has been noted that all markets saw a precipitous decline to varying degrees as a result of the crises of 2009-10 and the pandemic in 2020.

TABLE 1: DESCRIPTIVE STATS

	BRAZIL	RUSSIA	INDIA	CHINA	SA
Mean	108296.3	3316.597	46835.73	3348.534	3492.694
Maximum	130776	4287.52	61765.59	3715.37	4181.53
Minimum	63570	2058.12	25981.24	2660.17	2235.49
Std. Dev.	13804.59	505.2508	9414.444	259.315	351.9583
Skewness	-0.884047	-0.070696	-0.219499	-0.991659	-0.840256
Kurtosis	3.513877	2.034318	1.897953	2.794304	3.730584
Jarque-Bera	60.74153	17.06623	25.21282	71.23419	60.16189
Sum	46567423	1426137	20139363	1439869	1501858

The average of the returns for the five indices across all the periods has been positive and is maximum for Brazil followed by India. We can observe that the standard deviation for all the indices is high for Brazil and India which indicates that the BRICS markets were affected by COVID. Skewness in the case of none of the countries if zero means all five indices are not symmetric. In the case of BRAZIL and SA, the series also showed an excess kurtosis of above 3, indicating that the returns are not regularly distributed.

However, the data series must be made stationary before econometric modelling, which means that the mean and auto covariance of the series must be independent of time.

We evaluate and analyse the return series have some trend or not first. To apply different tests to a time series the data should have no trend. This is checked by conducting ADF test. the stationarity of the return series for the five BRICS markets using the ADF test. The returns are predicted to be nonstationary, i.e., to have a unit root, by the null hypothesis. According to the findings in Table 2, all five indices were stationary at the first difference but nonstationary at the level. The null hypothesis is thus disproved.

Table 2: Estimation Results of ADF Test

Countries	INDEX	At level		At first diff.	
		T-stat	P value	T-stat	P-value
BRAZIL	BOVESPA	-2.300818	0.4321	-13.82354	0.0000
RUSSIA	MOEX	-1.072976	0.931	-20.10846	0.0000
INDIA	SENSEX	-2.836714	0.1849	-20.33332	0.0000
CHINA	SHANGHAI COMP.	-1.969097	0.616	-19.64051	0.0000
SOUTH AFRICA	FTSE	-3.221069	0.0817	-18.49604	0.0000

As per the outcomes in the table the return series of the different nations under study the data is non- stationary at level at 5% level of significance and when their first difference is calculated all the series are stationary at 5% level of significance.

4.2 Estimation of the ARCH/GARCH

With time, volatility fluctuates; low changes are followed by low changes and substantial changes by high changes. It is quite evident from the graphs that there is volatility clustering in the five nations. So, we can say that there may be autocorrelation in volatility estimates. We can study this volatility by ARCH and GARCH models. Before applying the GARCH test I am checking the residual graph and also doing a Heteroscedasticity test to check the ARCH effect. Once it is proved that there is an ARCH effect then only GARCH test is applied. Residual graphs are given for Brazil(Fig.1), Russia(Fig.2), India(Fig.3), China(Fig.4) and South Africa(Fig.5) are given below.

Fig. 1 Residual Graphs-BRAZIL

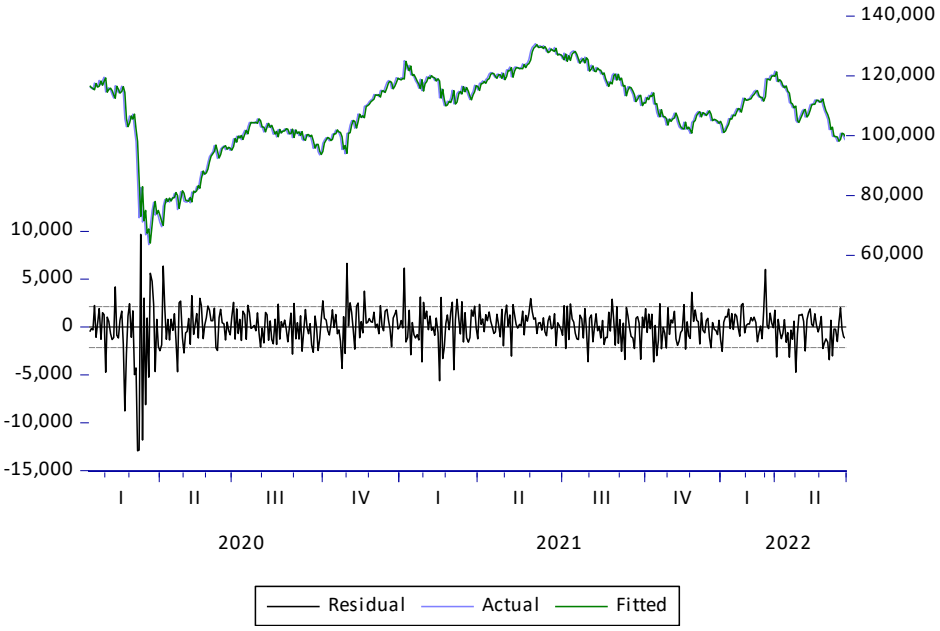


Fig. 2 Residual Graphs- RUSSIA

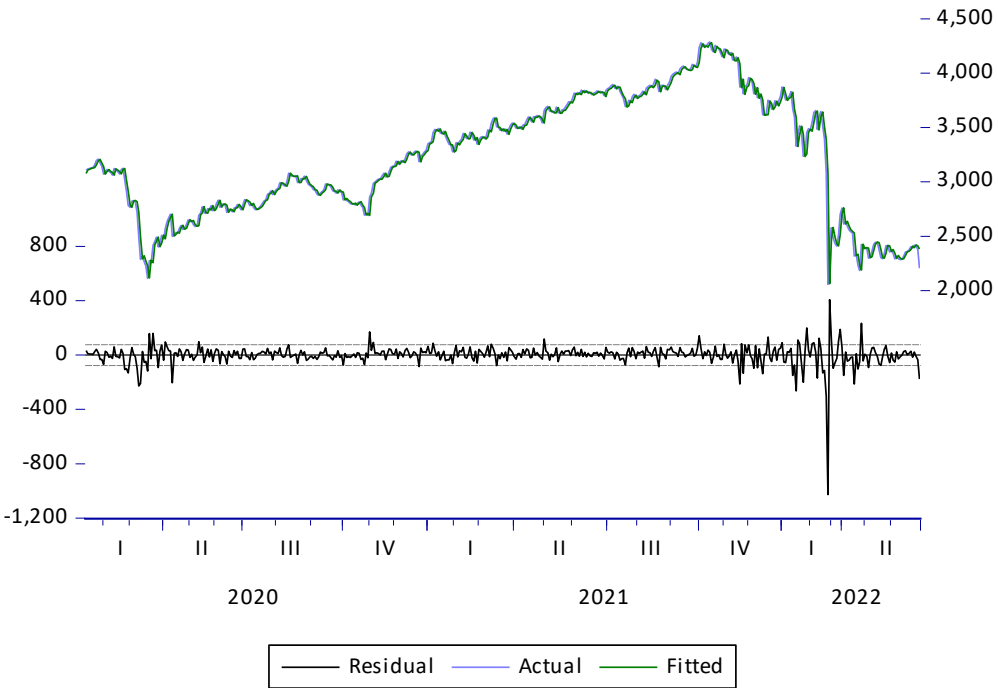


Fig. 3 Residual Graphs- INDIA

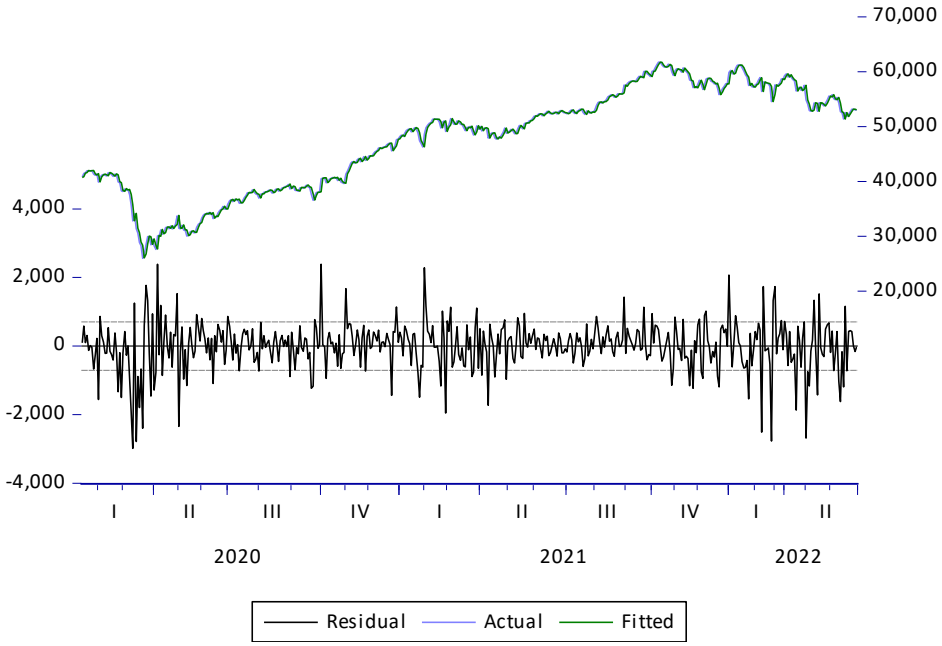


Fig. 4 Residual Graphs- CHINA

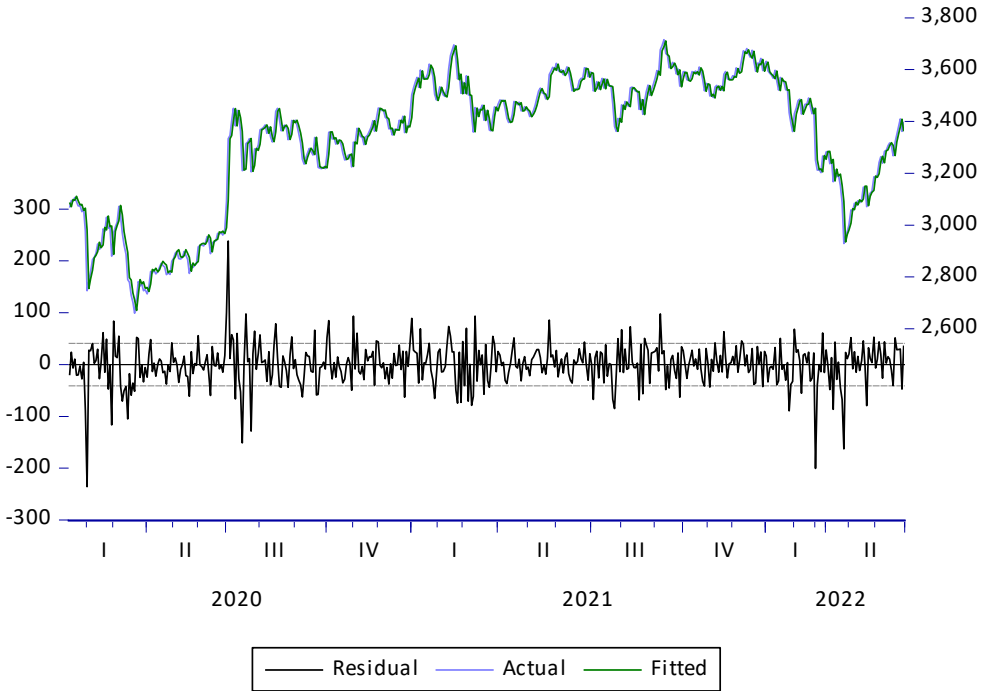
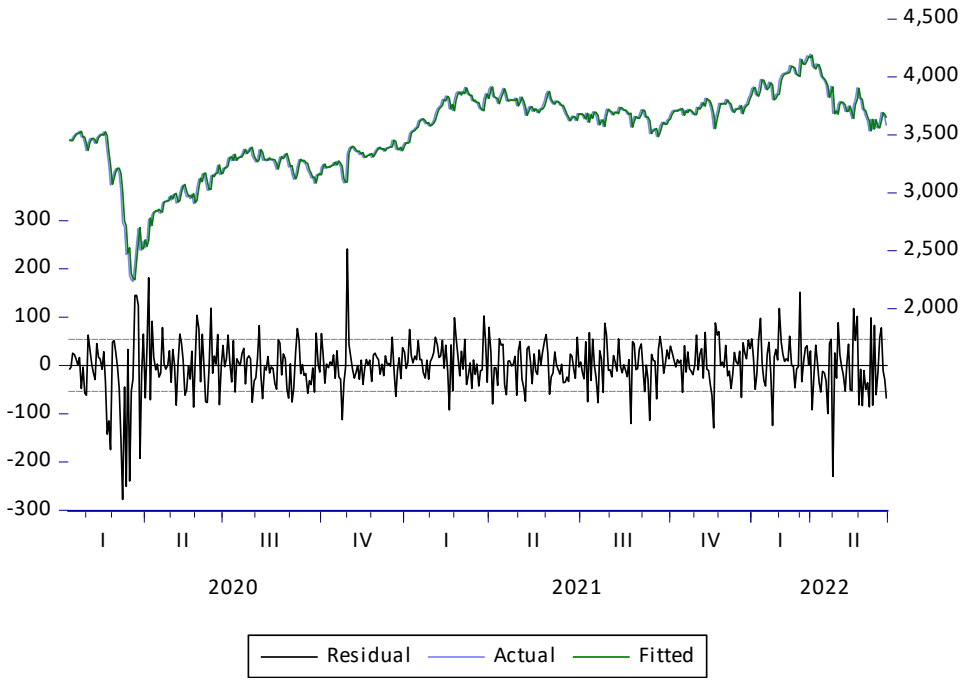


Fig. 5 Residual Graphs- SOUTH AFRICA



4.3 ARCH Test Hypothesis:

HO: Residual variance is constant (Homoscedastic)

H1: Residual variance is not constant(Heteroskedastic)

As the p-value <0.05, we can say that we are accepting H1 which means the ARCH effect is existing. After checking the existence of the ARCH effect we proceed with the GARCH test.

Table 3: Estimation Results of GARCH (1, 1)

	Variable	Coefficient	z-Statistic	Prob.
BRAZIL	C	387587.90	3.28	0.001
	RESID(-1)^2	0.11	4.89	0.000
	GARCH(-1)	0.78	15.62	0.000
RUSSIA	C	199.26	5.66	0.000
	RESID(-1)^2	0.32	11.71	0.000
	GARCH(-1)	0.69	30.21	0.000
INDIA	C	17129.86	3.50	0.0005
	RESID(-1)^2	0.09	4.97	0.000
	GARCH(-1)	0.88	38.69	0.000
CHINA	C	834.68	4.92	0.000
	RESID(-1)^2	0.32	7.40	0.000
	GARCH(-1)	0.22	1.99	0.0461
SA	C	338.79	3.00	0.0027
	RESID(-1)^2	0.17	4.51	0.000
	GARCH(-1)	0.71	10.32	0.000

Results in the above table state that the ARCH AND GARCH terms of Brazil, Russia, India, China, and South Africa all are sig. at a 5% level of significance. Furthermore, we can say that volatility in the indices of all five nations depends on their past squared residuals and also on their past volatility. The necessary condition of the GARCH Model, where the sum of Coefficients of ARCH and GARCH terms should be less than 1 to ensure the stationarity of the process. The results state that this condition is satisfying for all nations except in the case of Russia, which means variance is exponentially increasing over time. Volatility is very high in Russian Markets.

Also in the case of Brazil, Russia, India, and South Africa, the GARCH coefficient is at a higher side than the ARCH coefficient value, so we can say that **the volatility is long-lasting and clustering** (high fluctuations followed by high, low fluctuation followed by low changes).

4.4 EGARCH

The EGARCH model is prepared to see the leverage effect in the markets. The leverage effect is proof that negative news has a greater influence on volatility than some positive news. The leverage impact is explained as the result of a firm's share price declining, which raises its debt-to-equity ratio and raises the unpredictability of returns to equity holders.

The EGARCH model is found to be suitable for all the five indices by using residual diagnostics (Correlogram Squared Residual, ARCH LM test, Normality test).

The outcomes are given in the following table 4.

Table 4: Results of EGARCH (1, 1)

		Constant	GARCH	LEVERAGE	ARCH
BRAZIL	Coeff.	2.02	0.13	-0.22	0.86
	Prob.	0.00	0.02	0.00	0.00
RUSSIA	Coeff.	0.24	0.26	-0.19	0.95
	Prob.	0.00	0.00	0.00	0.00
INDIA	Coeff.	0.76	0.06	-0.20	0.94
	Prob.	0.00	0.05	0.00	0.00
CHINA	Coeff.	3.50	0.52	-0.11	0.47
	Prob.	0.00	0.00	0.00	0.00
SA	Coeff.	0.64	0.15	-0.20	0.90
	Prob.	0.00	0.00	0.00	0.00

We can see the coefficient of EGARCH term (leverage effect) is negative and sig. at 5% for all five nations. This shows asymmetric volatility and the because of this there is an inverse correlation among historical returns and the volatility in future returns. The repercussion of unpleasant news on fluctuation in stock indices is much more than the result of good news on the volatility of the stock index.

5. SUMMARY & CONCLUSION

Due to the globalization of economies, emerging economies have attracted a lot of attention among investors all over the world. People from all over the world are interested to understand the volatility in stock markets and the factors responsible for it. In order to give some insigts to the investors about the same this study is conducted to analyze how the recent pandemic has created disruptions in the returns on investments in these economies. We made use of different variations of GARCH modelling to test the returns generated from the selected stock market indices of these countries. Tests for understanding the level of volatility, asymmetric movement in volatility and leverage effect was conducted. The outcomes indicate that the volatility is highly persistent in all five indices. The asymmetries in volatility and leverage effect have been observed in all the indices. This indicates that the BRICS nations indices are significantly affected by negative information i.e., COVID-19. The findings of this paper will benefit portfolio managers and policymakers in order to make informed decisions regarding the allocation of funds to portfolios, managing the risk, and also in the formulation of monetary policies.

REFERENCES:

Aggarwal, R., Inclan, C., & Leal, R. (1999). Volatility in Emerging Stock Markets. *Journal of Financial and Quantitative Analysis*, *34*(1), 33–55. https://doi.org/10.2307/2676245

Alexakis, C., Eleftheriou, K., & Patsoulis, P. (2021). COVID-19 containment measures and stock market returns: An international spatial econometrics investigation. *Journal of Behavioral and Experimental Finance*, *29*, 100428. https://doi.org/10.1016/j.jbef.2020.100428

Ashraf, B. N. (2020). Stock markets' reaction to COVID-19: Cases or fatalities? *Research in International Business and Finance*, *54*, 101249. https://doi.org/10.1016/j.ribaf.2020.101249

Baek, S., Mohanty, S. K., & Glambosky, M. (2020). COVID-19 and stock market volatility: An industry level analysis. *Finance Research Letters*, *37*, 101748. https://doi.org/10.1016/j.frl.2020.101748

Bhar, R., & Nikolova, B. (2007). Analysis of Mean and Volatility Spillovers Using BRIC Countries, Regional and World Equity Index Returns. *Journal of Economic Integration*, *22*, 369–381.

Bora, D., & Basistha, D. (n.d.). The outbreak of COVID-19 pandemic and its impact on stock market volatility: Evidence from a worst-affected economy. *Journal of Public Affairs*, *n/a*(n/a), e2623. https://doi.org/10.1002/pa.2623

Chai, S., Zhang, Z., Du, M., & Jiang, L. (2020). Volatility Similarity and Spillover Effects in G20 Stock Market Comovements: An ICA-Based ARMA-APARCH-M Approach. *Complexity*, *2020*, e8872307. https://doi.org/10.1155/2020/8872307

Chen, Y., Yu, L., & Gang, J. (2021). Half-day trading and spillovers. *Frontiers of Business Research in China*, *15*(1), 1. https://doi.org/10.1186/s11782-021-00097-7

Cheung, W., Fung, S., & Tsai, S.-C. (2010). Global capital market interdependence and spillover effect of credit risk: Evidence from the 2007–2009 global financial crisis. *Applied Financial Economics*, *20*(1–2), 85–103. https://doi.org/10.1080/09603100903262962

Corbet, S., Hou, Y. (Greg), Hu, Y., Oxley, L., & Xu, D. (2021). Pandemic-related financial market volatility spillovers: Evidence from the Chinese COVID-19 epicentre. *International Review of Economics & Finance*, *71*, 55–81. https://doi.org/10.1016/j.iref.2020.06.022

Das, S. (2021). The Time–Frequency Relationship between Oil Price, Stock Returns and Exchange Rate. *Journal of Business Cycle Research*, 1–21. https://doi.org/10.1007/s41549-021-00057-3

Elhini, M., & Hammam, R. (2021). The impact of COVID-19 on the standard & poor 500 index sectors: A multivariate generalized autoregressive conditional heteroscedasticity model. *Journal of Chinese Economic and Foreign Trade Studies*, *14*(1), 18–43. https://doi.org/10.1108/JCEFTS-08-2020-0049

Gao, X., Ren, Y., & Umar, M. (2021). To what extent does COVID-19 drive stock market volatility? A comparison between the U.S. and China. *Economic Research-Ekonomska Istraživanja*, *0*(0), 1–21. https://doi.org/10.1080/1331677X.2021.1906730

Gulzar, S., Kayani, G. M., Xiaofeng, H., Ayub, U., & Rafique, A. (2019). Financial cointegration and spillover effect of global financial crisis: A study of emerging Asian financial markets. *Economic Research-Ekonomska Istraživanja*, *32*(1), 187–218. https://doi.org/10.1080/1331677X.2018.1550001

Guru, B. K., & Das, A. (2021). COVID-19 and uncertainty spillovers in Indian stock market. *MethodsX*, *8*, 101199. https://doi.org/10.1016/j.mex.2020.101199

Hasan, M. B., Mahi, M., Sarker, T., & Amin, M. R. (2021). Spillovers of the COVID-19 Pandemic: Impact on Global Economic Activity, the Stock Market, and the Energy Sector. *Journal of Risk and Financial Management*, *14*(5), Article 5. https://doi.org/10.3390/jrfm14050200

Huynh, T. L. D., Nasir, M. A., & Nguyen, D. K. (2020). Spillovers and Connectedness in Foreign Exchange Markets: The Role of Trade Policy Uncertainty. *The Quarterly Review of Economics and Finance*. https://doi.org/10.1016/j.qref.2020.09.001

Jacob, P. (2016). *Spillover Effect of the Oil Prices on the Indian Stock Market* (SSRN Scholarly Paper ID 3299818). Social Science Research Network. https://doi.org/10.2139/ssrn.3299818

Jebran, K., & Iqbal, A. (2016). Dynamics of volatility spillover between stock market and foreign exchange market: Evidence from Asian Countries. *Financial Innovation*, *2*(1), 3. https://doi.org/10.1186/s40854-016-0021-1

Khan, K., Zhao, H., Zhang, H., Yang, H., Shah, M. H., & Jahanger, A. (2020). The Impact of COVID-19 Pandemic on Stock Markets: An Empirical Analysis of World Major Stock Indices. *The Journal of Asian Finance, Economics and Business*, *7*(7), 463–474. https://doi.org/10.13106/jafeb.2020.vol7.no7.463

Liu, H., Manzoor, A., Wang, C., Zhang, L., & Manzoor, Z. (2020). The COVID-19 Outbreak and Affected Countries Stock Markets Response. *International Journal of Environmental Research and Public Health*, *17*(8), Article 8. https://doi.org/10.3390/ijerph17082800

Malepati, V. (2016). *A Study on Volatility in Indian Stock Market* (SSRN Scholarly Paper ID 2890890). Social Science Research Network. https://doi.org/10.2139/ssrn.2890890

Natarajan, V. K., Robert Raja Singh, A., & Chidham Priya, N. (2014). Examining mean-volatility spillovers across national stock markets. *Journal of Economics, Finance and Administrative Science*, *19*(36), 55–62. https://doi.org/10.1016/j.jefas.2014.01.001

Ozili, P., & Arun, T. (2020). Spillover of COVID-19: Impact on the Global Economy. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3562570

Panda, P. (2019). Spillovers and financial integration in emerging markets: Analysis of BRICS economies within a VAR-BEKK framework. *International Journal of Finance & Economics*, *26*. https://doi.org/10.1002/ijfe.1801

Sharma, G. D., Erkut, B., Jain, M., Kaya, T., Mahendru, M., Srivastava, M., Uppal, R. S., & Singh, S. (2020). Sailing through the COVID-19 Crisis by Using AI for Financial Market Predictions. *Mathematical Problems in Engineering*, *2020*, e1479507. https://doi.org/10.1155/2020/1479507

Shehzad, K., Xiaoxing, L., Bilgili, F., & Koçak, E. (2021). COVID-19 and Spillover Effect of Global Economic Crisis on the United States' Financial Stability. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.632175

Si, D.-K., Li, X.-L., Xu, X., & Fang, Y. (2021). The risk spillover effect of the COVID-19 pandemic on energy sector: Evidence from China. *Energy Economics*, *102*, 105498. https://doi.org/10.1016/j.eneco.2021.105498

Singh, D., Theivanayaki, M., & Ganeshwari, M. (2021). Examining Volatility Spillover Between Foreign Exchange Markets and Stock Markets of Countries such as BRICS Countries. *Global Business Review*, 09721509211020543. https://doi.org/10.1177/09721509211020543

Wu, X., Zhu, S., & Wang, S. (2020). Research on Information Spillover Effect of the RMB Exchange Rate and Stock Market Based on R-Vine Copula. *Complexity*, *2020*, e2492181. https://doi.org/10.1155/2020/2492181

Youssef, M., Mokni, K., & Ajmi, A. N. (2021). Dynamic connectedness between stock markets in the presence of the COVID-19 pandemic: Does economic policy uncertainty matter? *Financial Innovation*, *7*(1), 13. https://doi.org/10.1186/s40854-021-00227-3

Zhang, W., & Hamori, S. (2021). Crude oil market and stock markets during the COVID-19 pandemic: Evidence from the US, Japan, and Germany. *International Review of Financial Analysis*, *74*, 101702. https://doi.org/10.1016/j.irfa.2021.101702

Table 1: Descriptive Statistics

	BRAZIL	RUSSIA	INDIA	CHINA	SA
Mean	108296.3	3316.597	46835.73	3348.534	3492.694
Maximum	130776	4287.52	61765.59	3715.37	4181.53
Minimum	63570	2058.12	25981.24	2660.17	2235.49
Std. Dev.	13804.59	505.2508	9414.444	259.315	351.9583
Skewness	-0.884047	-0.070696	-0.219499	-0.991659	-0.840256
Kurtosis	3.513877	2.034318	1.897953	2.794304	3.730584
Jarque-Bera	60.74153	17.06623	25.21282	71.23419	60.16189
Sum	46567423	1426137	20139363	1439869	1501858

Table 2: Estimation Results of ADF Test

Countries	INDEX	At level		At first diff.	
		T-stat	P value	T-stat	P-value
BRAZIL	BOVESPA	-2.300818	0.4321	-13.82354	0.0000
RUSSIA	MOEX	-1.072976	0.931	-20.10846	0.0000
INDIA	SENSEX	-2.836714	0.1849	-20.33332	0.0000
CHINA	SHANGHAI COMP.	-1.969097	0.616	-19.64051	0.0000

SOUTH AFRICA	**FTSE**	-3.221069	0.0817	-18.49604	0.0000

Fig. 1 Residual Graphs-BRAZIL

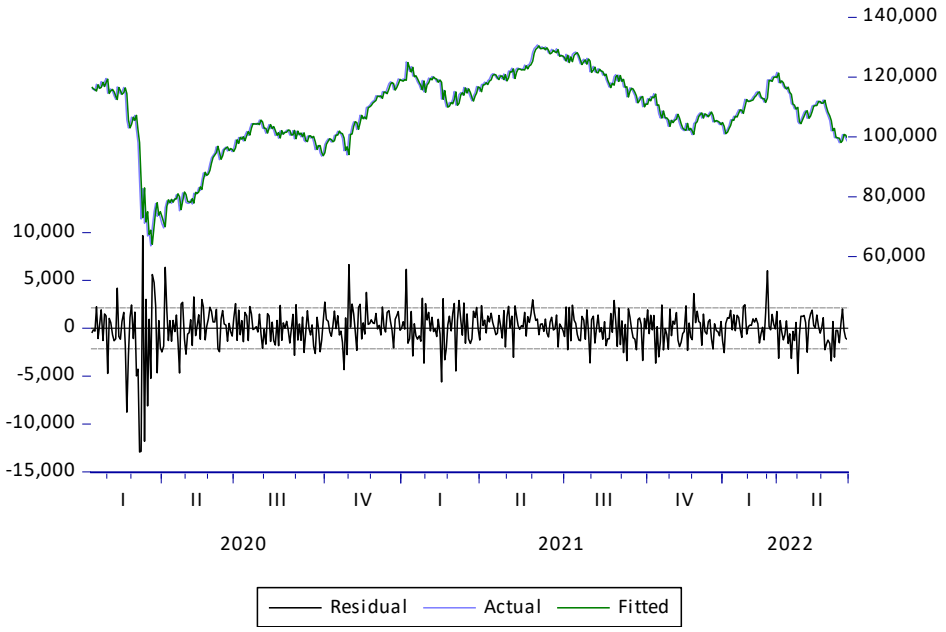


Fig. 2 Residual Graphs- RUSSIA

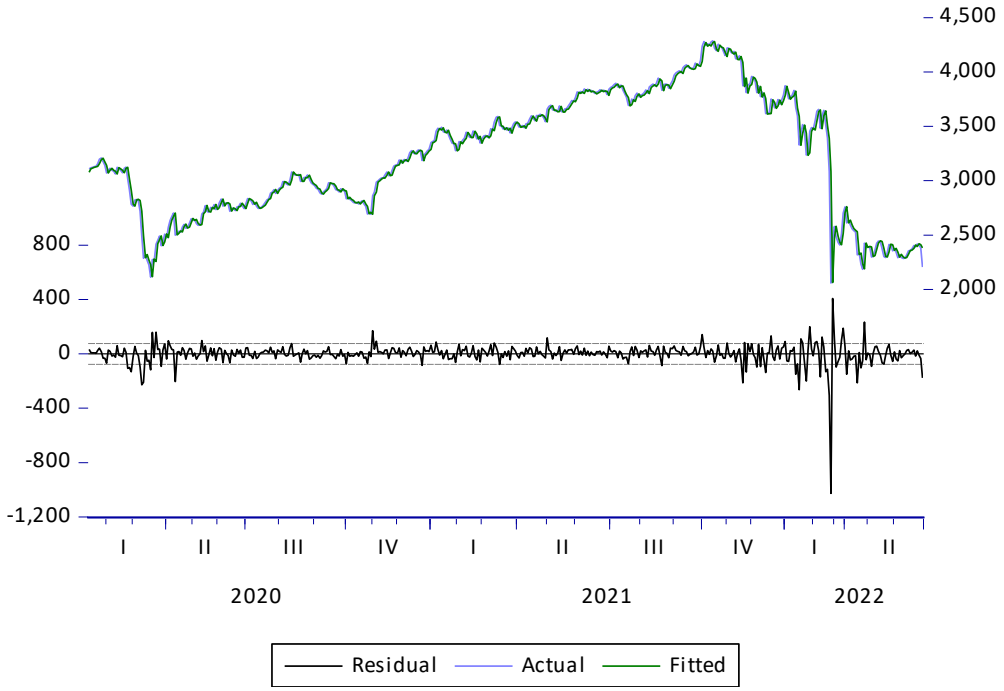


Fig. 3 Residual Graphs- INDIA

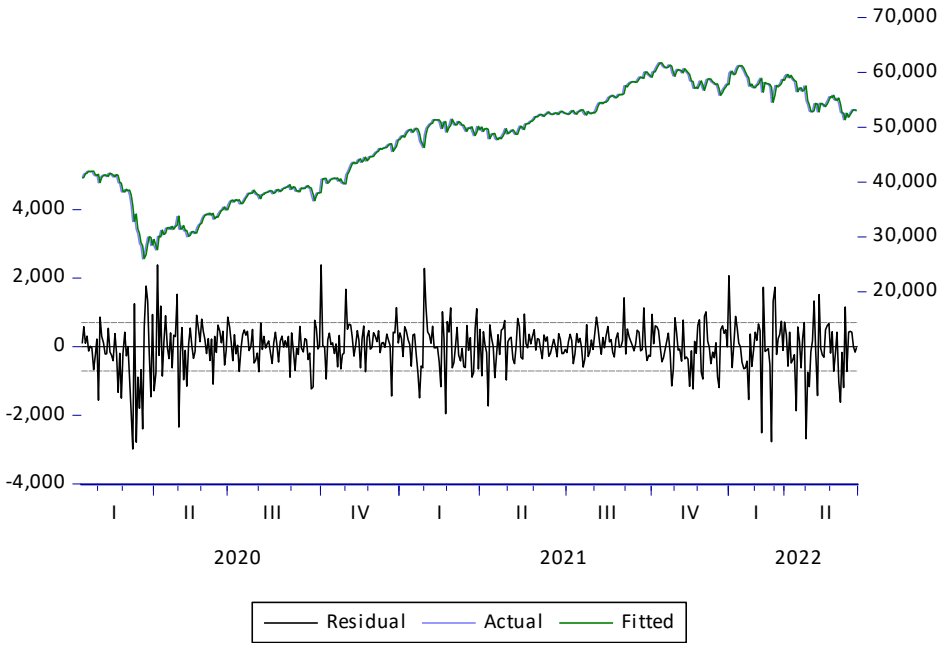


Fig. 4 Residual Graphs- CHINA

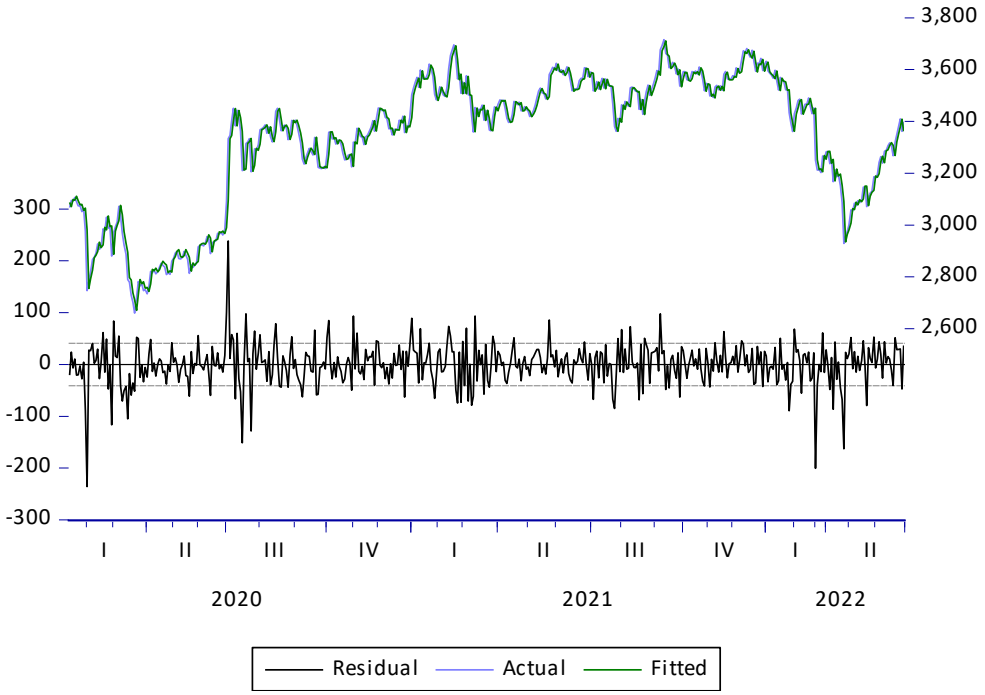


Fig. 5 Residual Graphs- SOUTH AFRICA

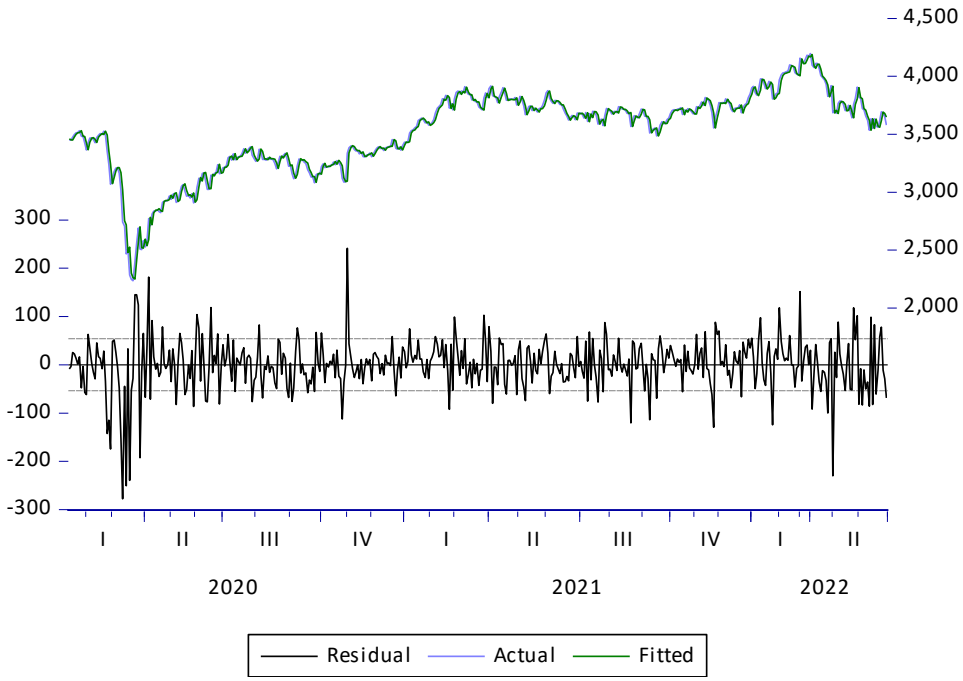


Table 3: Estimation Results of GARCH (1, 1)

	Variable	Coefficient	z-Statistic	Prob.
BRAZIL	C	387587.90	3.28	0.001
	RESID(-1)^2	0.11	4.89	0.000
	GARCH(-1)	0.78	15.62	0.000
RUSSIA	C	199.26	5.66	0.000
	RESID(-1)^2	0.32	11.71	0.000
	GARCH(-1)	0.69	30.21	0.000
INDIA	C	17129.86	3.50	0.0005
	RESID(-1)^2	0.09	4.97	0.000
	GARCH(-1)	0.88	38.69	0.000
CHINA	C	834.68	4.92	0.000
	RESID(-1)^2	0.32	7.40	0.000
	GARCH(-1)	0.22	1.99	0.0461
SA	C	338.79	3.00	0.0027
	RESID(-1)^2	0.17	4.51	0.000
	GARCH(-1)	0.71	10.32	0.000

Table 4: Estimation Results of EGARCH (1, 1)

		Constant	GARCH	LEVERAGE	ARCH
BRAZIL	Coeff.	2.02	0.13	-0.22	0.86
	Prob.	0.00	0.02	0.00	0.00
RUSSIA	Coeff.	0.24	0.26	-0.19	0.95
	Prob.	0.00	0.00	0.00	0.00
INDIA	Coeff.	0.76	0.06	-0.20	0.94
	Prob.	0.00	0.05	0.00	0.00
CHINA	Coeff.	3.50	0.52	-0.11	0.47
	Prob.	0.00	0.00	0.00	0.00
SA	Coeff.	0.64	0.15	-0.20	0.90
	Prob.	0.00	0.00	0.00	0.00