COVID-19 Pandemic and Volatility Spillover Effects on Foreign Exchange Rates

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Abstract

Purpose : The study aimed to examine the impact of COVID-19 on exchange rate volatility in five major emerging economies: the Indian rupee, Brazilian real, Mexican peso, Chinese yuan, and South African rand. Advanced statistical analysis techniques, including the GARCH (1,1) model and asymmetric volatility models, were employed to uncover significant insights.

Design/Methodology/Approach : The influence of unfavorable COVID-19 news on exchange rate volatility in the five key emerging nations described above was examined using sophisticated statistical analytic approaches, such as the GARCH (1,1) model and asymmetric volatility models.

Findings : The study found that past-day volatility greatly impacted current-day volatility, supporting the existence of the ARCH effect. Surprisingly, external independent variables—LBR, LCY, LMP, and LSR—demonstrated no significant impact on the volatility of LIR, highlighting susceptibility to internal shocks. The results of further using asymmetric volatility models to evaluate long-term consequences indicated that COVID-19 did not affect these variables. Exchange rate returns were not volatile even in the face of bad pandemic-related news.

Practical Implications : The study enhanced the body of knowledge on COVID-19's effects on currency exchange rates while offering managers and marketers useful advice on navigating currency volatility.

Originality : In contrast to other research, this study contributed to the body of knowledge by examining the effects of COVID-19 on exchange rate volatility within important emerging markets using advanced statistical approaches. It sheds light on the intricate dynamics of currency changes during crises, providing new insights that are beneficial to scholars and experts in the field of international finance.

Keywords : **volatility spillover, foreign exchange rates, emerging economies, GARCH**

JEL Classification Code : G2, G5, G6

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The COVID-19 pandemic has disrupted the global trade and development landscape, leading to a significant decline in international trade, foreign direct investment, and global growth. According to ILO & OECD (Organisation for Economic Co-operation and Development, 2020), the number of unemployed individuals worldwide reached 309 million in the second quarter of 2020 due to the impact of COVID-19.

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Government measures such as lockdowns have affected various industries (Ceylan et al., 2020). Although these actions were implemented to contain the spread of the virus, they have the potential to create long-term economic issues, such as reduced liquidity (De Vito & Gomez, 2020), increased debt (Zhang et al., 2020), heightened stock market volatility (Zaremba et al., 2020), diminished stock returns (Al-Awadhi et al., 2020; Negi et al., 2012), and a rise in bankruptcies (Akhtaruzzaman et al., 2021). According to the UN Trade & Development (2021), global output contracted by 3.5% in 2020, and it will take several years for global revenue to recover from the shock of the COVID-19 pandemic.

According to the OECD Report (COVID-19 and Global Capital Flows), the exchange rates of key emerging market economies (EMEs) have significantly decreased. The decline of the value of the currencies accelerated between the middle of February and the end of March in the year 2020 (refer to Figure 1). The currencies of advanced economies (AEs), including the US dollar (USD), the euro (EUR), and the Swiss franc (CHF), have generally appreciated, as Figure 2 illustrates. The Australian and Canadian currencies saw significant increases in value after experiencing significant declines in the first half of March.

Figure 1. ***Exchange Rates Jan–May 2020 (Selected Emerging Market Economies)***

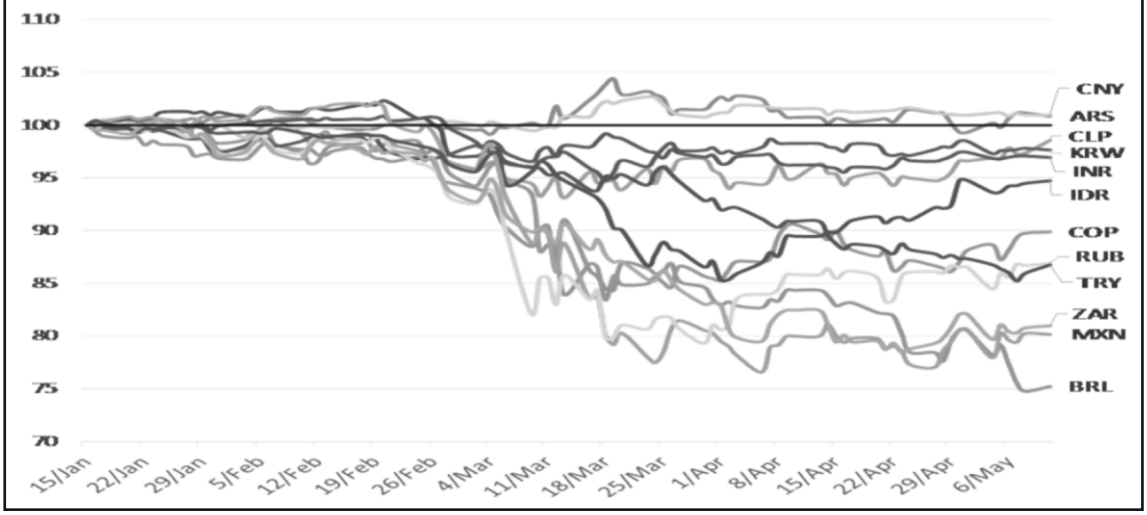
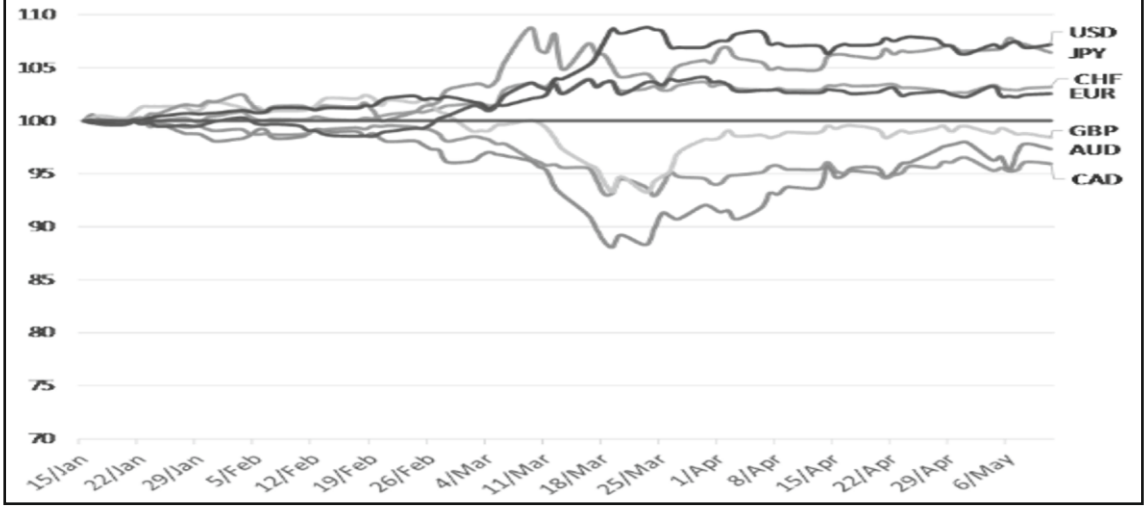


Figure 2. ***Exchange Rates – Selected Advanced Economies, Jan–May 2020***



The COVID-19 pandemic has triggered unprecedented volatility in financial markets worldwide, including foreign exchange markets (Ceylan et al., 2020; Negi et al., 2012). Policymakers, investors, and businesses navigating the post-pandemic economic landscape must comprehend how this volatility spreads internationally and impacts the currency rates of major emerging economies. There is still a large study gap in the thorough analysis of the spillover effects of volatility on foreign exchange rates in major emerging nations, despite the abundance of research on the immediate effects of COVID-19 on financial markets.

While some studies have examined the short-term effects of COVID-19 on exchange rate volatility in specific emerging economies, there is limited research that systematically investigates the spillover effects across multiple major emerging markets (Dikshita & Singh, 2019). Past research studies on volatility discussed less volatility spillover among currencies (Kushwah & Vigg, 2023; Muthukamu et al., 2024; Negi et al., 2010). The current research tries to study this volatility spillover effects on currencies of the COVID-19 pandemic and fill this gap. Through the identification and analysis of these spillover effects, the research advances our knowledge of the interdependence of the world's financial markets and provides investors and policymakers with information about the implications for risk management and exchange rate stability.

This study aimed to investigate how the negative shock caused by COVID-19 would impact the volatility of exchange rates in five emerging economies over the long term. Furthermore, we looked into how the Indian rupee was impacted by the volatile exchange values of the Chinese yuan, Brazilian real, Mexican peso, and South African rand. Median exchange rates were calculated against US dollars for the five emerging economies from April 1, 2019, to March 31, 2021, encompassing both the year prior to and the year following COVID-19. The insights gained from this study are significant for policymakers, financial investors, and individuals. It provides valuable insights into the behavior of exchange rates in response to negative news related to the pandemic, particularly in five developing economies.

Literature Review

The growth of cross-border trade has been made possible by the trend toward capital account liberalization, technical advancements, and currency speculation. As a result, the exchange rate has fluctuated (Vevek et al., 2022; Veeravel et al., 2021). The pandemic sent shocks to different parts of the world's economy in five waves, leading to a state of depression. It has impacted various aspects, including countries' price levels, GDP, employment, income, exchange rates, risk, and financial stability (Barua, 2020; Kushwah & Negi, 2023; Negi et al., 2012; Nathani & Kushwah, 2022; Riyazahmed & Sriram, 2024; Subba et al., 2023). Countries need to take the right steps to recover from the effects of the pandemic on both supply and demand. International commerce and increased exchange rate volatility have been studied by Huynh (2021) and a few other economists. Lal et al. (2023) and Soukotta et al. (2023) found that an increase in exchange rate volatility can negatively impact the volume of international trade. Long-term impacts of currency exchange rate fluctuations on global trade may include a potential disruption to a nation's trade balance.

Dineri and Çütçü (2020) examined the impact of new cases and deaths on the exchange rate of Turkey, using the exchange rate in US dollars as a dependent variable. Benzid and Chebbi (2020) suggested that the number of US cases positively impacted exchange rate volatility in countries. Iyke (2020) attempted to determine whether exchange rate volatility and returns could be predicted using information about the pandemic. The study concluded that COVID-19 has a bigger effect on volatility than returns in the short term by using a variety of tests and models, such as EGARCH. However, over an extended length of time, it becomes harder to predict volatility, while returns may be predicted with greater accuracy. Luckieta and Alamsyah (2020) aimed to demonstrate how the COVID-19 pandemic affected currency exchange rates at the Bank of Indonesia.

Villarreal-Samaniego (2021) studied whether there was a short-term or long-term relationship between the exchange rates of three oil-exporting countries (Brazil, Mexico, and Russia) and two oil-importing countries (Colombia and South Africa) with COVID-19 and crude oil prices. The results indicated that changes in the Brazilian real and South African rand were related to COVID-19, whereas the Russian ruble was unaffected due to the simultaneous depreciation of currencies and dropping oil prices. Feng et al. (2021) stated that as the number of confirmed cases rose, exchange rate volatility increased significantly. Exchange rate volatility decreased as a result of government responses to the outbreak, including public awareness campaigns, mobility restrictions, and school closures.

Sharma et al. (2019) investigated the link between government shutdowns and currency changes, finding that the latter tended to exacerbate volatility. They also demonstrated that the shutdown effect was at its peak one day after a shutdown and that it gradually faded for most currencies within five days. Hofmann et al. (2021) investigated the currency and bond markets in emerging economies to learn how they fared during the COVID-19 pandemic. The results indicated that countries with stronger policy frameworks might fare better in the event of COVID-19. Additionally, the spread between exchange rates and local currency bonds spiked, causing significant losses for portfolio investors who will need to rebalance their holdings to recover from the crisis. Raksong and Sombatthira (2021) examined the real effective exchange rates and whether or not there was a short- or long-term link, focusing on the growing economies of ASEAN and other nations. The results showed that currencies in countries with a trade deficit would see a decline in value while those in countries with a surplus would see a gain. The real effective exchange rate of ASEAN was mostly determined by governmental spending and foreign direct investment as a percentage of GDP. Financial capital has been pulled out of emerging market economies as a result of the pandemic, as noted by Marin and Corsetti (2020). The analysis found that the value of the US dollar rose against the currencies of the UK and seven other nations during the pandemic, but the value of the US dollar fell against the currencies of Japan and Europe.

By taking into account BRIICS economies, Garg and Prabheesh (2021) set out to characterize the connection between interest rate differentials and exchange rates during COVID-19. They discussed how important it is for investors to know how interest rates would vary throughout the pandemic in order to forecast currency rates and allocate their capital appropriately across all six economies. Oil prices and the performance of ten developing economies were analyzed by Živkov et al. (2019). We found that in 2008 and 2009, there was an inverse relationship between oil prices and currency rates by applying the phase difference method. The effects of COVID-19 confirmed cases and deaths in the most afflicted countries, such as China and the United States, were underlined by Li et al. (2021), particularly in the context of their respective currencies. Our data demonstrated that the number of COVID-19 deaths and cases recorded in a number of countries had a negative effect on those countries' currency exchange rates. The pandemic is undermining the financial foundations of both China and the United States, so its effects will be seen not just in the short term. In their study on the topic, Morina et al. (2020) found that low levels of exchange rate volatility are necessary for growth. The study also supported fixed capital development and trade openness as additional factors that support steady economic growth in the CEE region. The exchange rate's volatility decreased significantly as a result of COVID-19 (Corbet et al., 2021; Joshi, 2022; Negi et al., 2011). The epidemic had an impact on currencies and exchange rates because a country's currency is a key indicator of the health of its economy.

Despite the significant efforts put out in earlier research, more has to be done to understand how different currencies' volatility spills over, particularly during the COVID-19 epidemic. The goal of the current study is to close this gap and provide some solid evidence linking exchange rate volatility to other factors.

Data and Methodology

An important macroeconomic component that should ideally stay stable to encourage international trade and reduce economic risk and uncertainty is the exchange rate, which has a big impact on a nation's trade performance. However, the growth of international trade often leads to situations where the exchange rate becomes volatile. This study examines the long-term effect of the negative shock of COVID-19 on the volatility of the exchange rates of five emerging economies: India, China, Brazil, South Africa, and Mexico. The research takes a descriptive tack. Exchange rate information in US dollars for the five chosen emerging economies was gathered from the IMF's official websites between April 1, 2019, and March 31, 2021. This period included a year prior to and following the commencement of COVID-19, providing the necessary time range for study. In time series analysis, transforming a series into log returns is commonly used to reduce volatility (Kushwah & Garg, 2020; Lütkepohl & Xu, 2012). The equation used to calculate the log return is:

$$\text{Log } returns = \ln(Price\,t - Price\,t{-}1) \qquad (1)$$

The Jarque–Bera (JB) test checks for normality by comparing the skewness and kurtosis of a sample to the values found in a data set. The log returns are first subjected to the JB test for normality because this test performs well when compared to alternative normality tests. Due to the unreliability of alternative normality tests for large datasets, it is typically employed for such datasets. The assumption of normality in the data is the basis for this test. The complete equation of the JB test can be written as follows:

$$JB = n\,[(\sqrt{b}1)2/6 + (b2 - 3)2/24] \qquad (2)$$

where,
n is the sample size,
$\sqrt{b}1$ is the sample skewness coefficient,
$b2$ is the kurtosis coefficient.

In the case of a time series process, the term "strictly stationary" describes the situation where all of the variables involved are static during the entire series. Financial and economic time series are typically non-stationary; only through the process of differentiation can they be transformed into stationary series. This study examined and generated stationary series for all nations' exchange rates using the Augmented Dickey-Fuller (ADF) unit root test, one of several accessible tests for determining a unit root. If the data has a unit root, as the null hypothesis states, then the alternative hypothesis, that the data is stationary, is false. The complete ADF unit root test model can be written like this:

$$\Delta yt = \alpha + \gamma yt{-}1 + \Sigma\Delta yt{-}i + Pi = 1\varepsilon t \qquad (3)$$

where, yt data series is tested, and $\gamma t{-}i$ is the 1st difference in the tested series. Therefore, Ho: $\gamma = 0$ is the null hypothesis to test the data series and H1: $\gamma < 0$ is the alternative hypothesis used to check the unit root test, meaning that it is non-stationary when the ADF test value is less than a critical value.

GARCH (Generalized Autoregressive Conditional Heteroscedasticity) Model

The GARCH model was employed to investigate how volatility influences the exchange rates of five emerging economies over the long term. The ARCH model accommodates a basic linear conditional variance, whereas the

GARCH model extends this concept by including lagged conditional variances. By treating heteroscedasticity as a variable that can be modeled, GARCH enables more accurate predictions. Below is the general GARCH (*p,q*) model:

$$\sigma t2 = \omega + \Sigma\alpha iqi = 1ut - i2 + \Sigma\beta jpj = 1\sigma t - j \quad (4)$$

In this study, we employ the GARCH (1,1) model. The equations are outlined as follows:

$$rt\,(\text{Mean equation}) = \mu + ut \quad (5)$$

$$\sigma t2\,(\text{Variance question}) = \omega + \alpha ut - 12 + \beta\sigma t - 12 \quad (6)$$

The constant term in the variance equation is denoted as ω, while the shocks in volatility are represented by $ut-12$.

EGARCH Model

The EGARCH model is utilized to examine asymmetric volatility within the dataset. The EGARCH variance equation, assuming a normal distribution, is presented below:

$$\text{Ln}\,(\sigma\_t\text{^}2) = \omega + \beta\ln(\sigma\_t-1\text{^}2) + \gamma u\_t-1/\sqrt{(\sigma\_t-1\text{^}2)} + \alpha(|u\_t-1|/\sqrt{(\sigma\_t-1\text{^}2)} - \sqrt{(2\pi)}) \quad (7)$$

Below is a description of the variables utilized in the EGARCH model:

ω: Represents the intercept for the variance.

β: Denotes the coefficient (logged GARCH).

$(\sigma\_t-1\text{^}2)$: Refers to the logarithm of the GARCH term.

γ: Represents the scale of the asymmetric volatility.

$\gamma u\_t-1/\sqrt{(\sigma\_t-1\text{^}2)}$: Signifies the product of the last period's shock and the square root of the previous period's variance.

$[|u\_t-1|/\sqrt{(\sigma\_t-1\text{^}2)} - \sqrt{}]$ = value of last period's volatility shock.

TGARCH Model

The threshold GARCH (TGARCH) model is an extended model of the general GARCH used to check the leverage effect. The impact of both positive and negative news on a time series is asymmetrically examined. Through analysis of the data's mean and conditional variance using the following equation, it is determined that bad news has a greater impact:

$$\sigma\_t\text{^}2 = \omega + \Sigma jp = 1\,\beta\_j\,\sigma\_t-j\text{^}2 + \Sigma iq = 1\,\alpha\_i\,u\_t-i\text{^}2 + \Sigma rk = 1\gamma\_k\,u\_t-k\text{^}2\,I\_t-k \quad (8)$$

Serial correlation test, ARCH LM test, and normality test have been done in order to diagnose the significance of the GARCH model.

Analysis and Results

Descriptive Statistics

The statistical description of currency rates is presented in Table 1. The log returns of exchange rates for each country are used to compute several descriptive statistics. The mean, median, maximum, and minimum values, as well as standard deviation, skewness, and kurtosis, are all included in these statistics. These calculations are carried out. We observe that all countries' mean returns are positive except the Chinese yuan. We also find that the standard deviations of the Chinese yuan and Indian rupee are lesser than the other countries' exchange rate return, and South African rand has the highest standard deviation. The skewness value of all exchange rate returns falls between +1 and –1, which is within the acceptable range. On the other hand, all of the countries' kurtosis values are above the acceptable range of –3 to +3, which means that the normal distribution of the data has heavier tails.

Observations reveal that the mean returns of all countries are positive, except for the Chinese yuan. Furthermore, it is noted that the standard deviations of the Chinese yuan and Indian rupee are lower compared to those of other countries' exchange rate returns, while the South African rand exhibits the highest standard deviation. Skewness values for all exchange rate returns fall within the acceptable range of +1 to –1. However, the kurtosis values for all countries exceed the acceptable range of –3 to +3, indicating heavier tails in the normal distribution of the data. Kurtosis measures how peaked the data is, with a normal distribution having a skewness of zero and a kurtosis of three, signifying perfect symmetry around the mean.

Table 1 also highlights the JB test statistics, which should always be positive. If the value is not close to zero, it indicates that the sample data deviates from a normal distribution (Siddiqui & Kushwah, 2022). For all the time series of the study, the JB test values are notably high. The *p*-value of the JB test results, utilized to assess the normality of data by comparing skewness and kurtosis with the normal distribution, is less than 0.01 for all countries' exchange rate returns, leading to the rejection of the null hypothesis, stating that the data is normally distributed. Consequently, all the time series are determined to be non-normally distributed.

Unit Root Test

Before testing the impact of the pandemic on the exchange rate volatility of five emerging economies, all exchange rates underwent examination using the Augmented Dickey-Fuller test to ascertain stationarity. Each univariate series was found to be non-stationary. The presence of a unit root in exchange rate returns is well-established in the literature, evident in Asian markets (Masih & Masih, 2001), Indonesia, the Philippines,

Table 1. ***Jarque–Bera (JB) Test Results***

	Chinese Yuan	Brazilian Real	Indian Rupee	Mexican Peso	South African Rand
Mean	–2.01e–05	0.00034	5.41E–05	5.42E–05	3.69E–05
Median	0	0.00028	0	–4.44e–05	0
Maximum	0.00601	0.01903	0.00597	0.02179	0.06678
Minimum	–0.005992	–0.020023	–0.005726	–0.021958	–0.074075
Std. Dev.	0.00114	0.00474	0.00141	0.00415	0.00647
Skewness	84,028	–0.050511	–0.051269	0.76125	–0.893648
Kurtosis	8.707439	5.371344	5.452707	9.478329	61.40712
Jarque–Bera	671.0805	115.9557	124.0411	911.5686	70283.55
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

Table 2. *Unit Root Test*

Exchange Rates	*t*-statistics	*p*-value
Chinese Yuan	–14.1367	0
Brazilian Real	–21.0186	0
Indian Rupee	–22.168	0
Mexican Peso	–21.0049	0

Taiwan (Bekaert & Harvey, 1995), and other markets (Siddiqui & Kushwah, 2021). Therefore, we also employ a unit root test and conclude that all series contain unit roots (refer to Table 2). The first difference of all the time series is calculated, and the ADF test is repeated, and the findings confirm the stationarity of the time series with the first difference.

GARCH Test

The model used in this study aims to investigate the long-term impact of the volatility of the exchange rates of the Chinese yuan, Brazilian real, Mexican peso, and South African rand on the Indian rupee. Therefore, the dependent variable is the Indian rupee (LIR), while the independent variables or regressors are the exchange rates of the Chinese yuan (LCY), Brazilian real (LBR), Mexican peso (LMP), and South African rand (LSR).

GARCH (1, 1) MODEL

The mean equation is :

$$LIR = C1 + C2 * LBR + C3 * LCY + C4 * LMP + C5 * LSR + e \quad (9)$$

where,
LIR is the dependent variable,
C1 is the constant,
C2, *C3*, *C4*, and *C5* are coefficients,
LBR, LCY, LMP, and *LSR* are independent variables or regressors.

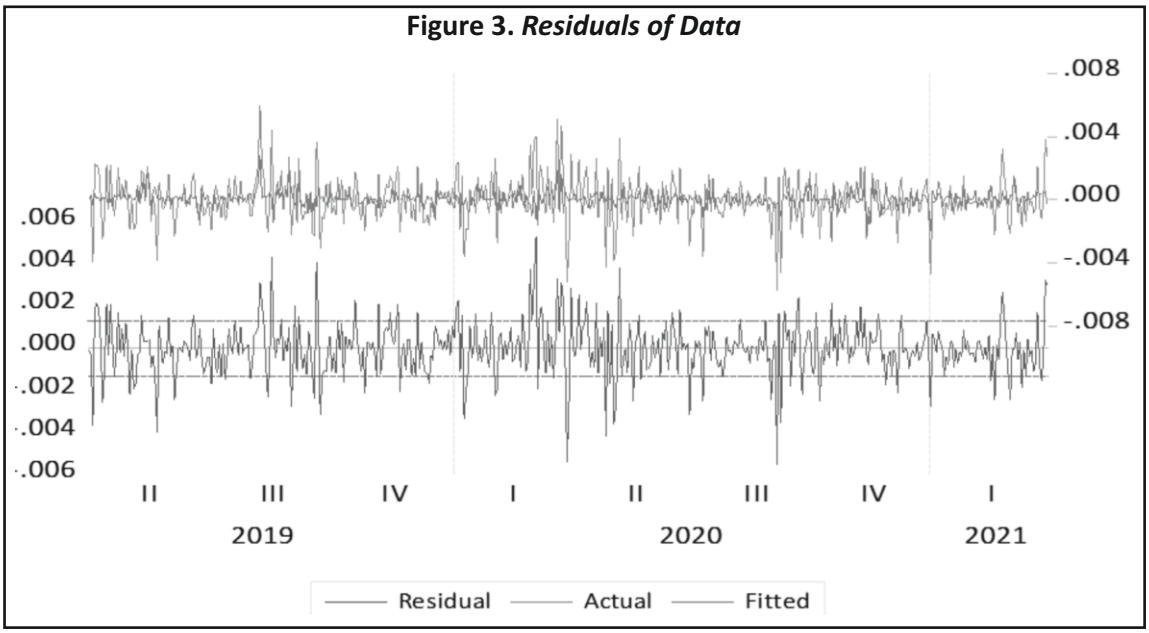
The variance equation is as follows:

$$GARCH = C(2) + C(3) * \text{RESID}(-1)^2 + C(4) * GARCH(-1) + C(5) * LBR + C(6) * LCY + C(7) * LMP + C(8) * LSR \quad (10)$$

where,
C2 is the constant.
C6, C3, C4, C5, and *C7* are coefficients.
LBR, LCY, LMP, and *LSR* are independent variables or regressors.

GARCH represents the volatility of the current period also the volatility of the Indian rupee in this case. GARCH (–1) is also called the GARCH term, which measures the impact of volatility of the previous day on today. RESID(–1)^2 is also called the ARCH term, which measures the impact of yesterday's returns on today's volatility. The above equation represents the GARCH (1,1) model because it contains one ARCH and one GARCH term. This model has the first-order ARCH term and first-order GARCH term, representing the internal shocks to the dependent variable.

Figure 3. ***Residuals of Data***



Residuals

Figure 3 denotes the residuals of the data. The evidence supporting the existence of conditional heteroscedasticity is the pattern in which periods of low volatility are followed by low volatility, and periods of high volatility are followed by high volatility. So, in cases when residuals behave in this way, we might present ARCH/GARCH models.

Results of GARCH (1, 1) Model

The *p*-value of 0.0008 in Table 3 is less than the significance level of 0.05, leading us to reject the null hypothesis. This indicates the presence of an ARCH effect, as denoted by the term RESID(–1)2. The existence of the ARCH effect suggests that yesterday's returns have an impact on today's returns. Furthermore, a GARCH effect is also evident, as indicated by the term GARCH(–1) with a *p*-value of 0.0000, which is less than 0.05. Therefore, at a 95% confidence level, we can conclude that yesterday's volatility will influence today's volatility. Regarding the other independent variables, namely LBR, LCY, LMP, and LSR, it can be observed that they do not significantly impact the volatility of LIR, as all their *p*-values are greater than 0.05. Consequently, we conclude that the Indian rupee is primarily affected by internal shocks rather than external independent variables.

Asymmetric Volatility Tests

These models are applied to investigate the long-term effect of the negative shock of COVID-19 on the volatility of exchange rates for five emerging economies.

TGARCH

Threshold GARCH (TGARCH) analysis explores the long-term impact of negative news on a time series, providing insights into the leverage effect. By examining both the mean and conditional variance of the data,

TGARCH analysis reveals that adverse news has a more pronounced effect. The results (refer to Table 3) show that there is no significant impact of COVID-19 on these variables because the coefficient of RESID(–1)^2*(RESID(–1)<0) is negative, and its *p*-value is 0.0190 < 0.01. Thus, at 99% confidence, negative news has no significant impact on the exchange rates in the long term.

EGARCH

The asymmetric volatility in the data is tested with the exponential GARCH (EGARCH) model. The EGARCH analysis reveals that C(4) demonstrates the leverage effect (refer to Table 3). However, it is noteworthy that the coefficient of C(4) appears positive yet insignificant. This implies that the negative news related to the pandemic did not induce any significant volatility in the exchange rate returns.

where, C2 is the constant, C3, C4, C5, C6, C7, C8, and C9 are coefficients. LBR, LCY, LMP, and LSR are independent variables or regressors. GARCH represents the volatility of the current period also the volatility of

Table 3. ***Results of GARCH (1,1), TGARCH, and EGARCH Model***

GARCH (1,1)	Variable	Coefficient	Std. Error	*z*-Statistics	Prob.
= *C*(2) + *C*(3) * *RESID* (–1)∧	*C*	2.49E–07	6.54E–08	3.809992	0.0001
2 + *C*(4) * *GARCH* (–1) + *C*(5) *	*RESID* (–1)∧2	0.115809	0.034406	3.365961	0.0008
LBR + *C*(6) * *LCY* + *C*(7) *	*GARCH*(–1)	0.755297	0.034406	14.32933	0.0000
LMP + *C*(8) * *LSR*	*LBR*	8.66E–06	1.02E–05	0.850777	0.3949
	LCY	–334E–05	3.31E–05	–1.009203	0.3129
	LMP	3.67E–05	2.19E–05	1.680664	0.0928
	LSR	1.30E–05	1.97E–05	0.662400	0.5077
TGARCH					
= *C*(2) + *C*(3) * *RESID* (–1) ∧ 2	*C*	2.17E–07	5.90E–08	3.686855	0.0002
+ *C*(4) * RESID(–1) ∧ 2 * (*RESID*	*RESID* (–1)∧2	0.192091	0.056494	3.400190	0.0007
(–1) < 0) + *C*(5) * *GARCH* (–1) +	*RESID*(–1) * (*RESID*(–1)<0)	–0.137349	0.058556	–2.345600	0.0190
C(6) * *LBR* + *C*(7) * *LCY* +	*GARCH*(–1)	0.767281	0.046427	16.52673	0.0000
C(8) * *LMP* + *C*(9) * *LSR*	*LBR*	2.35E–06	1.13E–05	0.207724	0.8354
	LCY	–5.92E–05	3.48E–05	–1.700317	0.0891
	LMP	4.62E–05	2.26E–05	2.044000	0.0410
	LSR	5.24E–06	1.84E–05	0.285235	0.7755
EGARCH					
= *C*(2) + *C*(3) * *ABS*(*RESID* (–1)/@*SQRT*	*C*(2)	–1.712812	0.406476	–4213805	0.0000
(*GARCH*(–1))) + *C*(4) * *RESID*(–1)/	*C*(3)	0.165493	0.040213	4.115355	0.0000
@*SQRT*(*GARCH*(–1) + *C*(5)*	*C*(4)	0.057767	0.033631	1.717688	0.0859
LOG(*GARCH* (–1) + *C*(6)*	*C*(5)	0.879913	0.030295	29.04522	0.0000
LBR + *C*(7) * *LCY* + *C*(8) *	*C*(6)	11.83543	9.285757	1.274578	0.2025
LMP + *C*(9) * *LSR*	*C*(7)	–16.16178	22.25909	–0.726076	0.4678
	C(8)	10.78245	8.877837	1.214535	0.2245
	C(9)	6.470733	10.36273	0.624424	0.5323

the Indian rupee in this case. GARCH (–1) is also called the GARCH term, which measures the impact of volatility of the previous day on today. RESID(–1)^2 is also called the ARCH term, which measures the impact of yesterday's returns on today's volatility.

Model Fit

These tests were carried out by the study in order to assess the suitability of the models and tests employed. Three tests on the residuals were run in order to accomplish this.

Serial Correlation test

In this analysis, the study investigates the presence of serial correlation in the residuals to assess their autocorrelation. The null hypothesis posits no serial correlation within the residuals. The software (Eviews) executed 36 iterations, yielding a table with probability values all-surpassing 0.05 (refer to Table 4). Consequently, the null hypothesis is accepted, signifying the absence of serial correlation. This indicates that the series exhibits random movements. The lack of serial correlation is pivotal for ensuring the model's appropriateness in examining the link between COVID-19 and exchange rates.

Normal Distribution Test (Jarque–Bera)

The JB test results indicate a *p*-value below 0.05 (refer to Figure 4), which leads to the rejection of the null hypothesis that the data follow a normal distribution. This finding is unfavorable for the adequacy of the model.

Table 4. ***Results of Serial Correlation***

Date: 05/07/21 Time: 21:07
Sample: 4/01/2019 3/31/2021
Included observations: 494

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.032	-0.032	0.5150	0.473
		2	0.043	0.042	1.4287	0.490
		3	0.037	0.040	2.1194	0.548
		4	-0.012	-0.011	2.1874	0.701
		5	0.003	-0.001	2.1925	0.822
		6	0.002	0.001	2.1942	0.901
		7	-0.022	-0.021	2.4287	0.932
		8	-0.099	-0.101	7.3764	0.497
		9	-0.031	-0.037	7.8756	0.547
		10	-0.031	-0.023	8.3653	0.593
		11	-0.020	-0.012	8.5592	0.663
		12	-0.034	-0.034	9.1641	0.689
		13	-0.019	-0.018	9.3437	0.747
		14	0.004	0.007	9.3530	0.808
		15	-0.027	-0.028	9.7382	0.836
		16	-0.000	-0.014	9.7382	0.880
		17	0.061	0.055	11.665	0.820
		18	-0.024	-0.024	11.951	0.850
		19	-0.007	-0.021	11.978	0.887
		20	0.039	0.027	12.746	0.888
		21	-0.035	-0.035	13.371	0.895
		22	0.025	0.017	13.699	0.912
		23	-0.030	-0.037	14.153	0.922
		24	-0.035	-0.039	14.801	0.926
		25	0.005	0.010	14.813	0.946
		26	-0.058	-0.057	16.596	0.921
		27	-0.029	-0.035	17.038	0.930
		28	-0.008	-0.003	17.068	0.947
		29	-0.010	-0.006	17.124	0.960
		30	-0.036	-0.035	17.790	0.962
		31	-0.012	-0.025	17.862	0.971
		32	-0.027	-0.030	18.260	0.975
		33	0.037	0.033	18.978	0.976
		34	0.015	-0.000	19.103	0.981
		35	-0.039	-0.049	19.896	0.981
		36	0.020	0.003	20.113	0.985

*Probabilities may not be valid for this equation specification.

Figure 4. ***Results of the Normality Test***

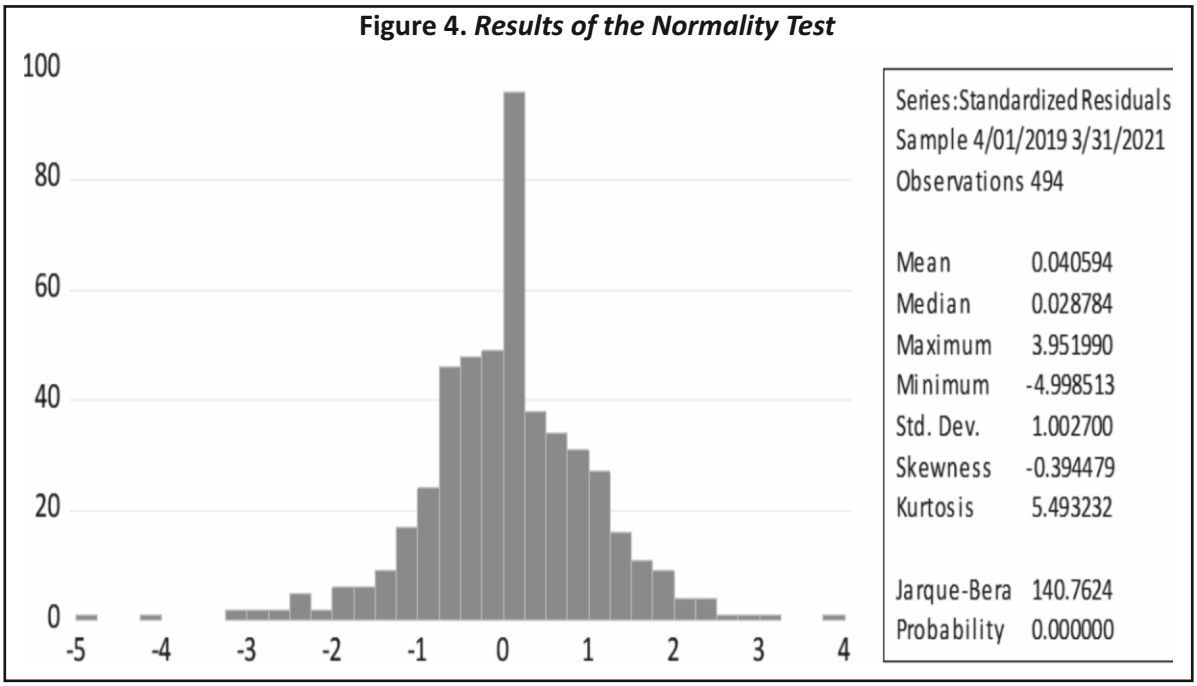


Table 5. ***Results of the Heteroskedasticity Test***

Heteroskedasticity Test : ARCH			
F-statistic	0.510228	Prob. *F*(1,491)	0.4754
Obs**R*-squared	0.511775	Prob. Chi-Square(1)	0.4744

Heteroscedasticity Test

The heteroscedasticity test yields a *p*-value of 0.4754 (refer to Table 5), which exceeds 0.05. Therefore, the null hypothesis that there is no heteroscedasticity effect in the residuals or ARCH effect cannot be rejected. This result also supports the adequacy of the model.

The overall outcome of the two tests conducted on residuals is favorable, with two out of three tests yielding desirable results. This is crucial for ensuring the validity of the model and enhancing its accuracy in forecasting the relationship between COVID-19 and exchange rates.

Implications

The study findings have several implications for industry managers, marketers, industry practitioners, and academic researchers. Managers can develop robust risk management strategies to identify the impact of exchange rate volatility on the profitability of the businesses. They can also implement the relevant risk mitigation strategies to improve the performance of the company. By implementing effective risk mitigation measures, managers can protect their organizations from adverse exchange rate movements and ensure financial stability in uncertain market conditions. Marketers can adapt their strategies and policies to account for exchange rate volatility and its implications for pricing and market expansion. Using the results and their findings, they can study and analyze the impact of exchange rate fluctuations on product pricing, profitability, and consumer

behavior in international markets. It will help them to make the right decisions and adjustments to maintain competitiveness and profitability in dynamic market environments.

Procurement specialists, finance departments, financial analysts, and legal experts are among the industry practitioners who would find the study valuable. These individuals are essential in controlling currency risk and guaranteeing regulatory compliance in their respective fields. The study's findings can be incorporated into company procedures to help them better manage currency fluctuations and lessen their effects on financial performance, regulatory compliance, and business operations. The study is also useful for enriching the academic literature by empirically investigating the repercussions of the COVID-19 pandemic on currency exchange rates in emerging economies. By giving empirical evidence and explaining the transmission mechanisms of external shocks to currency markets, the research substantially contributes to the existing knowledge base in international finance and macroeconomics.

Conclusion

The COVID-19 pandemic has intensely impacted the economies worldwide, including the financial markets, trade, exchange rates, GDP, etc. This study employs empirical analysis to explore the effects of the negative shock stemming from COVID-19 on the volatility of currency rates in five emerging economies. Furthermore, it assesses how the volatility of exchange rates for the Chinese yuan, Brazilian real, Mexican PESO, and South African rand influences the Indian rupee. The results from the JB test indicate that the data were not normally distributed. Subsequently, the ADF unit root test is conducted to assess and achieve stationarity for the exchange rate series of all countries. The findings reveal that all five countries' series are non-stationary initially, requiring integration at order 1 ($I(1)$). A reapplication of the ADF test confirms the attainment of stationarity for the series.

By conducting these analyses, we gained insights into the distribution patterns and stationarity of exchange rate data, essential for developing robust empirical models and understanding the dynamics of currency markets amidst the COVID-19 crisis. After that, because the residual graph unequivocally demonstrates the existence of conditional heteroscedasticity, the GARCH (1,1) model is utilized in order to examine the long-term impact that volatility had on the exchange rates of the Chinese yuan, Brazilian real, Mexican peso, and South African rand on the Indian economy. The findings demonstrate the existence of the ARCH effect, which indicates that there is a connection between the returns of the past and the returns of the present. The GARCH effect is also clearly apparent because the *p*-value is 0.00000.05; as a result, we are able to state that the volatility from yesterday will have an impact on the volatility from today. Because all of their *p*-values are higher than 0.05, the independent variables LBR, LCY, LMP, and LSR do not influence the volatility of LIR. As a result, we conclude that the Indian rupee is affected not by independent variables from the outside but rather by shocks from within.

Asymmetric volatility models are then used to evaluate their long-term effects. The TGARCH model's findings suggest that COVID-19 has no discernible effect on the variables being studied. Likewise, results from the EGARCH model indicate that news linked to the pandemic that is not positive does not cause volatility in currency rate returns. Both models agreed upon this point.

Limitations of the Study and Scope for Further Research

The study's scope is constrained primarily to assessing the influence of the COVID-19 pandemic on currency rate volatility in five emerging economies and its effect on the Indian rupee. However, this narrow focus may overlook other crucial factors impacting currency volatility, such as geopolitical tensions, economic policies, or broader global economic trends. Besides, the reliance on historical data may introduce limitations concerning data availability, accuracy, and timeliness, potentially compromising the study's generalizability. The study employs

econometric models like the JB test and GARCH (1,1) model ; inherent limitations within these models may exist, such as assumptions that fail to capture the full complexity of currency market dynamics, thus potentially biasing the analysis.

Subsequent investigations may broaden the scope of the analysis to include a greater number of rising economies and their interplay with the international currency markets. This broader scope would facilitate a more comprehensive understanding of how external shocks, like the COVID-19 pandemic, reverberate across various regions and economies, influencing currency volatility. We could also explore the incorporation of additional variables, such as macroeconomic indicators and political stability, to enrich the analysis and provide a more nuanced perspective on the drivers of currency volatility. A better understanding of the long-term effects of external shocks on currency markets would be possible with the help of longitudinal studies that follow currency volatility over time. These studies would provide insightful information about the persistence and evolution of volatility patterns. In addition complementing quantitative analysis with qualitative research methods, such as interviews or case studies, could provide richer insights into the underlying mechanisms driving currency volatility and its ramifications for businesses, consumers, and economies. Future studies may be able to overcome these obstacles and advance our understanding of the dynamics of currency markets during external shocks by pursuing these directions.

Authors' Contribution

Dr. Silky Vigg Kushwah conceived the idea and developed a quantitative design to undertake the empirical study. She collected the secondary data and cleaned it. Dr. Pushpa Negi extracted research papers with high repute, filtered these based on keywords, and generated concepts and wrote the literature review. Dr. Silky Vigg Kushwah analyzed the data using Eviews software, and Dr. Pushpa Negi wrote the interpretation of the results and drafted the manuscript in consultation with Dr. Silky Vigg Kushwah.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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