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Article

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Interaction between equity futures and spot markets during COVID-19 pandemic: a multi-market analysis

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Abstract

Using ABA research design and daily indices from South Africa, Eurozone, Japan and the United States of America, this study evaluates the interaction between equity index futures and spot markets *before*, *during* and *after* the COVID-19 pandemic. The results show evidence of cointegration between the equity futures and spot markets *before*, *during* and *after* the COVID-19 pandemic, a unidirectional causal relationship from the equity spot to the futures markets *before* and *after* the COVID-19 era, and bidirectional causality between the equity spot and futures markets during the COVID-19 pandemic, except for the South African markets. The results also show evidence of more spiky volatility during the COVID-19 pandemic era than was the case *before* and *after* the pandemic and the existence of bidirectional volatility transmission between the markets. The magnitude of transmission was stronger from the spot to futures markets during the COVID-19 pandemic era. Overall, the results suggest that the interaction between equity futures and spot markets varies according to the prevailing economic condition and the level of development of the markets.

Keywords COVID-19 pandemic and equity markets, Futures-stock markets relationship, Price discovery, Volatility transmission

Paper type Research paper

1. Introduction

This study aimed to establish the nature of interaction between equity futures contracts [1] and the underlying spot markets during the coronavirus pandemic era. Specifically, this study aims to analyse the cointegrating relationship, causal relationship and volatility interaction between equity futures and spot markets *before*, *during* and *after* the COVID-19 pandemic, using stock market indices from South Africa, Europe, Japan and the United States of America (USA). The interaction between equity futures and the spot markets has important implications for information flows between the markets, portfolio risk management, financial market regulation and the lead-lag connection (see, for example, Kawaller *et al.*, 1987; Chan, 1992; Lee and Yoon, 2017; Ahn *et al.*, 2019; Wats and Sikdar, 2022; Sundararajan and Balasubramanian, 2023). An understanding of the equity futures-spot markets' interaction during normal and crisis periods is crucial for financial market stability, as deciphering the markets' behaviour across these periods will minimise uncertainties. More so, a multi-market comparison of developed and developing markets will highlight interesting differences in their behavioural patterns, considering their diverse growth prospects and market risk exposure *before*, *during* and *after* the pandemic.

Many theories have been postulated to explain the interaction between futures contracts and spot markets, including the leverage trading hypothesis, the informed institutional

JEL Classification — G11, G13, G15, G32

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investor hypothesis, and the trading cost hypothesis. These theories attempt to explain the influence of one market on another. For example, the leverage trading hypothesis states that more leveraged securities tend to offer a better risk-return trade-off, which in turn attracts investors seeking assets with these characteristics (Kahraman and Tookes, 2017; McCullough, 2017; Peng and Hu, 2020; Rathgeber *et al.*, 2021). In view of the leveraged nature of futures contracts, this hypothesis supports a futures contracts-led price discovery process. The leveraged hypothesis is closely related to the informed institutional investor hypothesis, which postulates that the derivative market segment is dominated by informed institutional investors and, therefore, is expected to be more efficient in price discovery (Hendershott *et al.*, 2015). The trading cost hypothesis relates to the costs involved in trading and suggests that the market with lower costs will attract greater trade activity and thus lead the price discovery process (Kim *et al.*, 1999). These hypotheses support the futures-led returns causality and volatility transmission because leveraged trading and low-cost trading associated with futures contracts enhance speculative opportunities, which in turn increase market activities and volatility trading (Ahn *et al.*, 2019).

Contrary to the theoretical postulates that futures contracts trading enhances spot market volatility due to increased speculative activities, some studies evince that equity index futures trading reduces volatility through better price discovery and that volatility of the spot market leads volatility of the futures markets (see, for example, Lee and Yoon, 2017; Wats and Sikdar, 2022). There are also studies that suggest that the nature of the interaction between futures and spot markets' returns and volatility vary according to the stage of the markets' development as well as the prevailing business cycle in which they are considered (see, for example, Chan *et al.*, 1991; Schwert, 2011; Xue *et al.*, 2014; Chittedi, 2015; Emenike, 2021b; Das *et al.*, 2023; Su, 2023). This mixed evidence seems to imply that a reciprocal interaction could exist between the equity futures and the spot markets. Hence, there is a need for an answer to the question: how does the equity futures market interact with the equity spot market *before*, *during* and *after* the COVID-19 pandemic?

The existing literature on the interaction between equity futures and spot markets substantially ignores the African equity markets because of the nascent development of equity index futures [2] in the African financial markets (see, for example, Lee and Yoon, 2017; McCullough, 2017; Ahn *et al.*, 2019; We *et al.*, 2021; Wats and Sikdar, 2022; Ren *et al.*, 2022). Hence, African markets remain comparatively under-researched relative to the advanced economies' derivatives markets. The inclusion of an African dataset in the study is very important because it will shed light on any difference in the interaction between equity futures and spot markets in both advanced and emerging economies, as well as deepen our understanding of the global financial market behaviour [3]. Additionally, evidence from the African market will offer regional insight that will inform evidence-based investment decisions as well as promote financial literacy in Africa.

The results of this study contribute to literature on the equity futures-spot markets in many important ways. First, it establishes that the spot market dominates the information dissemination process in the South African stock market both *before* and *during* the COVID-19 pandemic. Second, it shows that the spot market has more influence on the futures market of the developed economies during the COVID-19 pandemic period. This market behaviour provides support to the equity-led price discovery process during prolonged crisis periods and seems to suggest that informed traders predominately trade on the spot market due to future uncertainties. Third, it informs regulators and investors not to disregard the information flows between the equity spot and futures markets in the formulation of the equity spot and futures investment policies at various investment horizons and at different market conditions.

The remainder of this paper is organised as follows: Section 2 primarily reviews related literature on the interaction between equity spot and futures securities. Section 3 outlines the techniques for data analysis and data. Section 4 presents and discusses the empirical results, and Section 5 concludes the paper. Overall, this paper contributes to the understanding of the relationship between equity spot and futures securities.

2. Literature review and research gap

Many theories postulate the lead-lag relationship and the dynamic interaction between equity futures and the spot markets. The informed institutional investors' hypothesis, for example, postulates that the derivatives market segment is dominated by informed institutional investors and should be more efficient in price discovery. This theory supports a futures-led price discovery process. Supporting this theory, [Chen \(2007\)](#) noted that the large and increasing presence of institutional investors both as owners of public companies and as traders in the U. S. stock markets has important implications for both firms' decisions and stock price behaviour. Similarly, [Hendershott et al. \(2015\)](#) and [Rathgeber et al. \(2021\)](#) agreed that institutional trading volume predicts the occurrence of news announcements, and that changes in leverage cause significant changes to the implied volatility of DAX companies. [Siddiqui and Roy \(2020\)](#) also documented evidence suggesting the dominance of institutional investors in the Chinese futures market.

Other futures-led price discovery theories include the leveraged trading and trading cost hypotheses. [Kim et al. \(1999\)](#) used the S&P 500, NYSE Composite, and MMI futures and across the respective cash indexes and reported that their findings are consistent with the trading cost hypothesis, which predicts that the market with the lowest overall trading costs will react most quickly to new information. [Kahraman and Tookes \(2017\)](#) reported that liquidity is higher when stocks become eligible for margin trading and that this liquidity enhancement is driven by margin traders' contrarian strategies. But the effect reverses during crises. [Peng and Hu \(2020\)](#) showed that leveraged trading has a threshold effect on the stock price crash risk and that at a low leverage ratio, leveraged trading reduces the stock price crash risk; however, as the leverage ratio increases and exceeds a certain threshold, leveraged trading asymmetrically increases the stock price crash risk. These theories tend to support the derivative markets leadership of the price movements in the underlying spot markets.

Many empirical studies have verified the interaction between equity futures and spot markets in both advanced and emerging economies. The majority of the studies were aimed at establishing the lead-lag connection between the instruments as a basis for investment and hedging decisions. Most of the evidence from the developed markets indicates that market index futures lead the corresponding spot market, as well as weak evidence of the spot market leading the futures market. [Kawaller et al. \(1987\)](#), for example, analysed the intraday price relationship between S&P 500 futures and the S&P 500 index using minute-to-minute data and reported that the S&P 500 futures led the S&P 500 index movements by 20 to 45 minutes, and the S&P 500 index also led the S&P 500 futures but not beyond one minute. [Stoll and Whaley \(1990\)](#), [Chan \(1992\)](#), and [Hiraki et al. \(1995\)](#) reported similar findings. [Xue et al. \(2014\)](#) and [Siddiqui and Roy \(2020\)](#) also showed that the causal influence from the futures market to the spot market was greater in the developed market than in the emerging markets. These studies suggest that the futures market has a stronger influence on the spot market in developed markets, but they also agree that the spot market improves its information transmission role with time horizon in developed markets. Therefore, both markets play a crucial role in the overall efficiency of the financial system.

Empirical studies on the volatility interaction between futures and cash markets also exhibit mixed evidence. [Lee and Yoon \(2017\)](#) reported, among others, that the volatility of the spot Korea composite stock price index (VKOSPI) led VKOSPI futures. [Ahn et al. \(2019\)](#) and [Ameur et al. \(2022\)](#) evinced that derivatives markets exhibit price leadership over the corresponding spot market and that increases in derivatives transaction costs do not immediately impede their roles in price discovery. [Ren et al. \(2022\)](#) agreed that derivatives markets lead the spot but added that the relation between derivatives and their underlying index reverses when the index return has a significantly higher mean value. In the same vein, [Jin et al. \(2022\)](#) reported that derivatives products led price discovery between the China Securities 300 index and its derivative. [Sundararajan and Balasubramanian \(2023\)](#) also reported that the US DJIA stock index strongly influences the price discovery of SGX Nifty futures and that past innovations in US markets impact the current volatility of SGX Nifty

futures. It thus appears that the volatility of the spot markets leads the volatility of the futures markets, while derivatives returns lead the spot returns.

In the African context, there is very scant evidence of the interaction between equity futures and the spot market because of the nascent stage of derivatives market development in Africa. McCullough (2017) established a long-run cointegrating relationship between the FTSE/JSE Top 40 spot, futures and ETF markets, and that the futures market remains the leading point in the price discovery process in South Africa.

Some studies analysed the interaction among financial markets during crisis periods. The existing evidence indicates that crisis periods are associated with very high levels of volatility in the financial markets (Schwert, 2011; Emenike, 2021b). Chittedi (2015) reported evidence of a significant increase in the mean correlation coefficient between the USA and Indian markets in the crisis periods compared to the pre-crisis period, thus concluding that contagion exists between the markets. Wats and Sikdar (2022) evinced that in the short run, during the crisis period, a unidirectional causality from futures to spot markets existed in advanced economies, while the opposite pattern was found in emerging economies. Thus, suggesting that the spot market dominates the information dissemination process in emerging markets. Das et al. (2023) reported that most of the G-7 countries experienced the highest risk during COVID-19 when compared to other crises, and that the pandemic increased interconnection among different markets within the group. Ajmi et al. (2021) and Arfaoui and Yousaf (2022) also reported evidence of intensified interdependence among the global financial and commodity markets during the COVID-19 pandemic. The increased interconnection among different markets within the group during the pandemic led to a greater degree of vulnerability to external shocks.

3. Data and methodology

3.1 Data

The data for this study are daily equity futures and spot price indices from four international stock markets, including South Africa, Europe, Japan and the United States of America (USA), and range from January 4, 2010 to May 20, 2024 [4]. The specific indices are South African (SA) 40 equity spot and futures [5], Euro Stoxx 50 equity spot and futures [6], Nikkei 225 equity spot and futures [7], and S&P 500 equity spot and futures [8]. The indices were collected from the database of [investing.com](https://www.investing.com) at <https://www.investing.com> [9]. For comparative analysis purposes, the study adopted the ABA research design [10], which allows division of the study period into three sub-periods: the *before*-COVID-19, *during*-COVID-19 and *after*-COVID-19 periods. The *before*-COVID-19 period covers from January 4, 2010 to 31 December 31, 2019; the COVID-19 period stretches from January 2, 2020 to December 31, 2021; and the *after*-COVID-19 period ranges from May 5, 2023 [11], to May 20, 2024. The variables of interest are the percentage daily equity spot and futures indices returns, which were obtained as the first difference of the natural logarithm of the equity spot and futures indices, as follows:

$$MR_{i,t} = (Ln(MI_{i,t}) - Ln(MI_{i,t-1})) * 100 \quad (1)$$

where $MR_{i,t} = (S_{mr,t} \text{ and } F_{mr,t})$ is a vector of daily percentage spot and futures market returns at time t , $MI_{i,t} = (S_{r,t} \text{ and } F_{r,t})$ is the current daily spot and futures markets indices at time t , $MI_{i,t-1} = (S_{r,t-1} \text{ and } F_{r,t-1})$ is the previous daily spot or futures markets indices at time $t-1$, and Ln is the natural logarithm.

3.2 Methodology

To investigate the interaction between equity spot and futures indices, and to establish whether there are changes in the relationship *before*, *during*, and *after* the COVID-19 pandemic, we employ Engle–Granger cointegration, Granger causality, and bivariate BEKK-GARCH (1,1)

models. The Engle–Granger cointegration model creates residuals based on a static regression and then tests the residuals for the presence of a unit-root as follows:

$$Sr_{i,t} = \alpha + \beta Fr_{i,t} + \mu_{1,t} \quad (2a)$$

$$Fr_{i,t} = \alpha + \beta Sr_{i,t} + \mu_{2,t} \quad (2b)$$

$$\Delta\mu_t = \alpha_1\mu_{t-1} + \varepsilon_t \quad (2c)$$

where $Sr_{i,t}$ is the spot returns for market i at time t , $Fr_{i,t}$ is the futures returns for market i at time, α and β are the cointegrating regression coefficients, $\mu_{1,t}$ and $\mu_{2,t}$ are the residuals, and $\Delta\mu_t$ is the estimated first difference residuals. There is cointegration between equity spot and futures market if the differenced residuals in Equation (2c) are stationary.

The Granger causality model examines whether a causal relationship exists between spot and futures market returns. This is to establish whether spot returns innovations in the market i influence equity futures returns in market i or inversely, whether futures returns innovations in the market i influence spot returns in the market i . The Granger causality test considers a bivariate autoregressive model of two variables Sr_t and Fr_t , as follows:

$$Sr_{i,t} = \alpha_0 + \sum_{i=1}^p \alpha_i Sr_{i,t-i} + \sum_{i=1}^p \beta_j Fr_{i,t-j} + \mu_{1t} \quad (3a)$$

$$Fr_{i,t} = \alpha_0 + \sum_{i=1}^p \lambda_j Fr_{i,t-j} + \sum_{i=1}^p \delta_i Sr_{i,t-i} + \mu_{2t} \quad (3b)$$

where $Sr_{i,t}$ is the spot return for market i , $Fr_{i,t}$ is the futures return for market i , and p is the maximum number of lagged observations considered, which helps to capture any potential patterns in the data. Using a sample F -test, a significant f -statistic implies that lagged changes in the futures returns Granger cause changes in the spot returns (Emenike, 2021a, b). Unidirectional causality would be established if there was significant causality from the spot returns to the futures returns without a feedback response from the futures returns to spot returns, and vice versa. Bidirectional causality would exist if there was a feedback causal relationship between the two markets.

The bivariate BEKK-GARCH (1,1) model was employed to evaluate the nature of volatility interaction between the selected equity futures and spot markets. The model was first proposed by Baba, Engle, Kraft, and Kroner, and later developed by Engle and Kroner (1995). The model is commonly used in financial econometrics for modeling multivariate volatility because it allows measurement of the interaction between volatilities and co-volatilities of two or more series. It also provides more flexibility in terms of estimating correlations among volatilities and ensures that the variance-covariance matrix is positive definite without any restrictions on the parameters (Bauwens et al., 2006; Emenike, 2021a). The conditional variance–covariance matrix of equations in the BEKK model depends on the squares and cross products of innovation ε_t derived from the mean equation specified according to Belhassine (2020) in 4a:

$$MR_{i,t} = \mu_i + \theta MR_{t-i} + \varepsilon_t \quad (4a)$$

$$H_t = C' C + A' \varepsilon_{t-1} \varepsilon_{t-1}' A + B' H_{t-1} B \quad (4b)$$

where μ_i is the constant, $MR_{i,t}$ is the equity (spot and futures) markets returns at time (t), and ε_t is the error term. The conditional variance equation is expressed in Equation (4b), where H_t is the conditional variance matrix. C , A , and B are parameter matrices: C is a 2×2 lower triangular matrix with three parameters: A is a 2×2 square matrix that shows how conditional

variances correlate with past squared errors; and B is a 2×2 square matrix that measures the effect of past conditional variances on the current conditional variances and the degree of persistence in the volatility of the markets (Emenike, 2020). The parameter matrices from Eq. (4b) can be represented as follows:

$$\begin{aligned} \begin{bmatrix} h_{1,1,t} & h_{1,2,t} \\ \cdot & h_{2,2,t} \end{bmatrix} &= \begin{bmatrix} c_{1,1}^0 & c_{1,2}^0 \\ 0 & c_{2,2}^0 \end{bmatrix} \begin{bmatrix} c_{2,2}^0 & c_{2,1}^0 \\ 0 & c_{1,1}^0 \end{bmatrix} \\ &+ \begin{bmatrix} a_{1,1}^* & a_{1,2}^* \\ a_{2,1}^* & a_{2,2}^* \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,1,t-1}^2 & \varepsilon_{1,1,t-1}\varepsilon_{2,2,t-1} \\ \varepsilon_{1,1,t-1}\varepsilon_{2,2,t-1} & \varepsilon_{2,2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{1,1}^* & a_{1,2}^* \\ a_{2,1}^* & a_{2,2}^* \end{bmatrix} \\ &+ \begin{bmatrix} b_{1,1}^* & b_{1,2}^* \\ b_{2,1}^* & b_{2,2}^* \end{bmatrix}' \begin{bmatrix} h_{1,1,t-1} & h_{1,2,t-1} \\ h_{2,1,t-1} & h_{2,2,t-1} \end{bmatrix} \begin{bmatrix} b_{1,1}^* & b_{1,2}^* \\ b_{2,1}^* & b_{2,2}^* \end{bmatrix} \end{aligned} \quad (5)$$

where $h_{1,1,t}$ denotes the conditional variance of the spot market, $h_{1,2,t}$ the covariance of spot and futures markets, and $h_{2,2,t}$ the conditional variance of the futures market. If the diagonal coefficients $a_{1,1,t}$ ($a_{2,2,t}$) are significant, it indicates that the current conditional variance of $h_{1,1,t}$ ($h_{2,2,t}$) is correlated to its past squared errors. Similarly, the significance of the lagged variance $b_{1,1,t}$ ($b_{2,2,t}$) indicates that the current conditional variance of $h_{1,1,t}$ ($h_{2,2,t}$) influences its past conditional variance. The significance of the off-diagonal parameters (i.e. $A_{(1,2), (2,1)}$ and $B_{(1,2), (2,1)}$) are evidence in support of shock and volatility transmission between equity futures and spot markets.

The Wald test would be used to confirm the significance of the off-diagonal parameters of the BEKK-GARCH-(1,1) model estimates. The null hypothesis for volatility transmission from the spot to the futures markets is $A_{1,2} = B_{1,2} = 0$ and implies the absence of volatility transmission. Conversely, $A_{2,1} = B_{2,1} = 0$ indicates the absence of volatility transmission from the equity futures market to the spot market. Rejection of these null hypotheses would evince volatility interaction between the spot and the futures markets.

The parameters of the above specifications were estimated by maximizing the log-likelihood function and by assuming that errors are normally distributed (Ajmi et al., 2021). The conditional log-likelihood function is expressed as follows:

$$L(\theta) = T \ln(2\pi) - \frac{1}{2} \sum_{t=1}^T \ln |H_t| + \varepsilon_t' H_t^{-1} \varepsilon_t \quad (6)$$

where the component θ is the estimated parameter vector T is the number of observations. K denotes the number of variables considered for the analysis

The Ljung and Box Q (L-B Q) test statistic, and the Lagrange multiplier (LM) diagnostic tests were used to examine adequacy of the bivariate BEKK-GARCH (1,1) model.

4. Empirical results

4.1 Descriptive statistics

Table 1 reports the preliminary analysis for the equity futures and spot indices daily returns. The average return series is zero for all the spot returns *before*, *during* and *after* the COVID-19 pandemic periods, except for the S&P 500, which had a positive return *before* and *after* the pandemic, as well as the Nikkei 225, which had a positive return, after the pandemic. While the

Table 1. Preliminary analysis for international equity futures and spot markets daily returns

	Before COVID				During COVID				After COVID			
	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500
<i>Panel I: spot return series</i>												
Mean	0.03	0.02	0.03	0.04	0.05	0.02	0.04	0.08	-0.01	0.05	0.11	0.09
%												
Min	-4.05	-9.01	-10.56	-6.90	-10.45	-13.24	-6.27	-12.77	-2.93	-2.98	-2.69	-1.65
Max	4.68	5.90	7.43	4.63	9.06	8.83	7.73	8.97	3.82	2.30	2.84	2.09
Std. dev	1.04	1.19	1.33	0.93	1.58	1.58	1.42	1.65	1.04	0.76	1.09	0.73
Skew	-0.13***	-0.31***	-0.55***	-0.52***	-0.68***	-1.36***	0.10	-1.05***	0.34**	-0.13	-0.04	-0.10
Ex.	1.34***	3.93*	5.31***	4.74***	9.84***	13.98***	4.10***	14.89***	1.03***	1.03***	-0.23	-0.19
Kurt												
J-B stat	193.7***	1417.8*	2647.5***	2118.1***	2058.7***	4345.1***	341.3***	4750.4***	16.07***	11.98***	0.63	0.74
LBQ	152.2***	147.4*	90.6***	198.6***	108.8***	86.2*	63.9***	354.2***	44.12**	39.23	16.83	37.85
McL	802.6***	1741.1*	447.5***	2056.3***	626.9***	242.1***	382.3***	787.1***	37.13	36.49	58.67***	35.67
ADF (L)	-1.60	-1.07	-0.63	-0.59	-1.03	-1.06	-1.02	-0.71	-2.77	-0.29	-1.25	-0.71
ADF (R)	-51.07***	-46.30***	-48.21***	-48.85***	-14.61***	-23.55***	-21.25***	-30.96***	-15.90***	-15.56***	-16.24*	-14.59***
<i>Panel II: futures return series</i>												
Mean	0.03	0.02	0.03	0.04	0.04	0.02	0.05	0.07	0.00	0.05	0.11	0.08
Min	-5.89	-8.94	-9.07	-7.50	-10.50	-11.99	-8.94	-10.96	-2.94	-3.09	-2.95	-1.70
Max	5.27	5.97	7.42	5.30	7.67	9.30	7.50	9.34	4.71	2.33	2.94	2.08
Std. dev	1.12	1.20	1.05	0.94	1.56	1.66	1.44	1.59	1.02	0.79	1.04	0.71
Skew	-0.19***	-0.40***	-0.44*	-0.61***	-0.91***	-1.04***	-0.48***	-1.16***	0.38***	-0.17	-0.08	-0.04

(continued)

Table 1. Continued

	Before COVID				During COVID				After COVID			
	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500
Ex. Kurt	2.13***	3.86***	4.35***	5.72***	7.56	10.07***	5.97***	15.08***	1.72***	0.95***	0.04	0.11
J-B stat	493.3***	1399.4***	1776.6***	3078.4***	1262.9***	2263.7***	764.4***	5179.4***	38.2***	10.87***	0.30	0.23
LBQ	159.5***	125.1***	113.5***	158.4***	77.0***	93.7***	73.3***	294.6***	47.78**	44.29**	31.27	37.48
McL	779.5***	1454.7***	566.6***	1549.1***	540.9***	365.0***	361.4***	841.3***	33.37	37.04	33.71	31.77
ADF (L)	-1.43	-2.12	-0.76	-0.69	-1.07	-1.12	-1.07	-0.70	-2.56	-0.44	-1.45	-0.82
ADF (R)	-39.18***	-46.56***	-48.54***	-48.76***	-23.89***	-24.26***	-22.83***	-31.63***	-15.52***	-15.64***	-15.93***	-15.12***

Note(s): ***, ** and * refer to 1%, 5 and 10% levels of significance, respectively. Mean is the percentage daily return for the equity spot and futures return series. Std. dev. is the standard deviations, and skew. is the skewness for the return series. Min and max are the minimum and maximum daily percentage returns, respectively. LBQ and McL are Ljung–Box Q tests and McLeod–Li statistics estimated to evaluate the existence of serial correlation and heteroscedasticity in the residuals and squared residuals of the mean model. The lag lengths selected by Akaike information criterion (AIC) for both the spot and futures returns in the *before* COVID-19 periods are 92 for Euro Stoxx 50, Nikkei 225 and S&P 500, and 99 for SA 40; 44 lags were selected for the COVID-19 period, and 31 lags were selected for the *after* COVID-19 period. The ADF (L) and (R) are the augmented Dickey–Fuller unit root test level and return series. The null hypothesis of the ADF test is that a time series contains a unit root. The critical values for ADF level and return series, at the 5% significance level, are -2.863, -2.867 and -2.873 for the *before*, *during* and *after* the COVID-19 periods, respectively

Source(s): Table by author

S&P 500 has the highest annualized spot returns *before* COVID-19 (10.92%) and *during* COVID-19 (19.5%), Nikkei 225 has the highest returns after the pandemic. The returns of the futures market are similar to those of the spot market for all periods. Observe from the standard deviations for spot returns that the Nikkei 225 had the highest annualized volatility *before* (18.6%) and *after* (16.8%) the COVID-19. But *during* the COVID-19 pandemic era, the S&P 500 became the most volatile (20.7%), whereas the Nikkei 225 became the least volatile (19.2%). In the futures market, the Eurp Stoxx 50 was the most volatile before and during the COVID-19 pandemic, but the Nikkei 225 became the most volatile after the pandemic.

All the spot returns were negatively skewed *before* and *during* the pandemic except for Nikkei 225, which was not skewed. After the pandemic, however, all the series are not skewed, except for the South Africa spot return, which is positive. Similarly, the futures returns are all negatively skewed for all the markets *before* and *during* the pandemic. But there is no evidence of skewness *after* the COVID-19 pandemic, except for South Africa, which shows positive skewness in futures returns.

Notice also that all the spot and futures returns are leptokurtic both *before* and *during* the pandemic periods, but the COVID-19 era has a fatter tail than *before* the COVID-19 period. The Jarque–Bera statistics reject the normal distribution for the spot returns in both periods. After the pandemic, however, there is no evidence of leptokurtosis in both the spot and futures returns, except for the South Africa return series, which are leptokurtic. The S&P 500 and Nikkei 225 returns appear to be normally distributed after the pandemic.

The LB-Q and McLeod-Li (MCL) tests indicate evidence of serial correlation and heteroscedasticity, respectively, in all the spot and futures return series. After the pandemic, however, there appears to be no evidence of serial correlation in the S&P 500 and Nikkei 225 spot and futures returns.

The null hypothesis of the unit root was rejected from the estimates of the ADF unit root test for all the spot and futures return series in all three periods. This suggests that the spot and futures returns are stationary.

4.2 Results of the cointegrating relationship between international equity futures and spot markets

Table 2 reports the results of the residual-based unit root test obtained from the Engle–Granger cointegrating regression model. Notice that there is evidence of cointegration between the spot and futures markets *before*, *during* and *after* the COVID-19 pandemic. The estimates from the residual-based unit root test show that the absolute value of the test statistic for *before* COVID-19 (−10.8514), *during* COVID-19 (−10.6715) and *after* COVID-19 (−3.0625) is greater than the conventional critical tau (t) value for the SA40 spot and SA40 futures indices. Since the absolute value of the computed t values is greater than the conventional critical tau values, we reject the null hypothesis of no cointegration between SA40 spot and futures markets.

These results, therefore, indicate evidence of a cointegrating relationship between the equity spot and futures markets in South Africa and thus suggest that as the expiration date approaches, the futures price converges with the spot price. This finding is the same for the Euro Stoxx 50, the S&P 500 and the Nikkei 225 spot and futures markets. This conclusion implies that there is no change in the cointegration relationship between equity spot and futures markets across time. The evidence of cointegration between equity spot and futures markets for SA40, Euro Stoxx 50, S&P 500 and Nikkei 225 is similar to the findings of Sundararajan and Balasubramanian (2023), who reported, among others, that the Indian Nifty index futures traded on the offshore Singapore Exchange are cointegrated with the USA Dow Jones Industrial Average stock index.

4.3 Results of the causal relationship between international equity futures and spot markets

Table 3 reports the results of the pairwise Granger causality test estimated to evaluate the interaction between the equity futures and spot markets in South Africa (SA40), Europe (Euro

Table 2. Results of cointegration test for international equity futures and spot markets

	Lags	Critical value 1%	Critical value 5%	Test statistic
<i>Before COVID-19</i>				
SA40 spot and SA40 futures	0/4	-4.3328	-3.7847	-10.8514***
Euro stoxx 50 spot and futures	0/4	-4.3338	-3.7853	-10.3474***
Nikkei 225 spot and futures	0/4	-3.78526	-4.33379	-5.14761***
S&P 500 spot and futures	1/4	-3.78465	-4.33278	-7.43892***
<i>During COVID-19</i>				
SA40 spot and futures	0/4	-4.3577	-3.7997	-10.6715***
Euro stoxx 50 spot and futures	1/4	-4.3569	-3.7993	12.1125***
Nikkei 225 spot t and futures	2/4	-4.35870	-3.80035	-5.83144***
S&P 500 spot and futures	4/4	-4.35774	-3.79976	-5.40324***
<i>After COVID-19</i>				
SA40 spot and futures	¼	-3.94272	-3.36171	-3.20587*
Euro stoxx 50 spot and futures	2/4	-3.94187	-3.36124	-3.13329*
Nikkei 225 spot t and futures	0/4	-3.94204	-3.36133	-4.20807***
S&P 500 spot and futures	¼	-3.94254	-3.36162	-4.31334***

Note(s): ***, ** and * indicate significant at 1%, 5 and 10% levels of significance. The null hypothesis is no cointegration (i.e. residual has a unit root). Critical values are computed from MacKinnon for 2 Variables. The after-COVID-19 pandemic 10% critical value for all the market series is -3.062

Source(s): Table by author

Stoxx 50), Japan (Nikkei 225) and the USA (S&P 500) *before*, *during* and *after* the COVID-19 pandemic. From the results of the *before*-COVID-19 pandemic era displayed in *Panel A* of [Table 3](#) observe that there is evidence of unidirectional causality from the equity spot to the futures markets, except for the Nikkei 225, which appears segmented. These results suggest that the equity spot market influences the equity futures market *before* the COVID-19 pandemic.

The results of the COVID-19 pandemic era displayed in *Panel B* of [Table 3](#) show evidence of bidirectional causality between equity spot and futures markets at the conventional significance levels, except for South Africa, which maintained unidirectional causality from spot to equity futures returns. There is therefore evidence of feedback causal relationship between the equity spot and futures markets during the COVID-19 pandemic, but the magnitude of causality is stronger from the spot markets. It thus appears that the spot market has more influence on price discovery than the futures market in South Africa.

The results of the *after*-COVID-19 pandemic era shown in *Panel C* of [Table 3](#) indicate evidence of unidirectional causality from the equity spot to the futures markets, except for the South African market. These results are similar to the *before*-COVID-19 pandemic results.

The results of the pairwise Granger causality test suggest that there is an existence of a feedback causal relationship between the equity spot and futures markets, which was not the case *before* and *after* the COVID-19 pandemic.

These findings do not align with the informed institutional investors' hypothesis, which expects the futures market segment to be more efficient in price discovery ([Hendershott et al., 2015](#)). The South African results also support the findings of [Wats and Sikdar \(2022\)](#), who showed that in the short run, during the crisis period, a unidirectional causality from futures to spot was found in advanced economies, while the opposite pattern was found in emerging economies.

More so, the results suggest that the developed spot markets had more influence on the equity futures market during the COVID-19 pandemic era. This market behaviour seems to suggest a spot market-led price discovery process during a normal period and a feedback

Table 3. Results of Granger causality tests for international equity futures and spot markets

	Lags	F-statistic	p-value	D-W stat
<i>Panel A: before COVID-19 pandemic</i>				
SA40 spot → SA40 futures	23	(23,2427) 8.985	0.000***	2.005
SA40 futures → SA40 spot		(23,2426) 0.956	0.520	2.003
Euro stoxx 50 → Futures	6	(6,2131) 4.372	0.000***	2.001
Euro stoxx 50 futures → spot		(6,2130) 1.380	0.218	1.999
Nikkei 225 spot → futures	1	(1,2472) 0.590	0.442	1.999
Nikkei 225 futures → spot		(1,2471) 0.361	0.547	1.998
S&P 500 spot → futures	5	(5,2500) 96.231	0.000*	2.002
S&P 500 futures → spot		(5,2499) 1.445	0.204	1.999
<i>Panel B: during COVID-19 pandemic</i>				
SA40 spot → futures	8	(8,477) 15.252	0.000***	2.007
SA40 futures → SA40 spot		(8,476) 1.395	0.196	2.001
Euro stoxx 50 stock → futures	8	(8,477) 2.425	0.014**	2.055
Euro stoxx 50 futures → spot		(8,489) 3.383	0.000***	1.977
Nikkei 225 spot → futures	7	(7,466) 11.425	0.000***	2.008
Nikkei 225 futures → spot		(7,465) 1.963	0.058*	2.007
S&P 500 spot → futures	11	(11,471) 18.748	0.000***	1.988
S&P 500 futures → spot		(11,470) 1.751	0.059*	1.999
<i>Panel C: after COVID-19 pandemic</i>				
SA40 spot → futures	1	(1,247) 0.045	0.831	1.992
SA40 futures → SA40 spot		(1,246) 2.676	0.103	1.981
Euro stoxx 50 stock → futures	2	(2,250) 14.731	0.000***	2.029
Euro stoxx 50 futures → spot		(2,249) 1.453	0.235	1.997
Nikkei 225 spot → futures	2	(2,247) 5.210	0.006***	2.014
Nikkei 225 futures → spot		(2,246) 0.049	0.953	1.993
S&P 500 spot → futures	6	(6,233) 10.394	0.000***	2.028
S&P 500 futures → spot		(6,232) 1.244	0.284	1.992

Note(s): ***, ** and * refer to 1%, 5%, and 10% statistical significance levels, respectively. D–W stat is the Durbin–Watson test statistic. → indicate the direction of causality. Lag lengths were selected using AIC

Source(s): Table by author

interactive price discovery process during a prolonged crisis period because of market factors associated with future uncertainties.

4.4 Volatility interaction between international equity futures and spot markets

Table 4 reports the results of the bivariate BEKK-GARCH (1,1) model estimated to assess the volatility interaction between equity futures and spot returns *before*, *during*, and *after* the COVID-19 pandemic for the SA40, Euro Stoxx 50, Nikkei 225, and S&P 500. The panels I, II and III of Table 4 illustrates that the diagonal parameters are statistically significant. The $C_{1,1}$, and $C_{2,2}$, which are coefficients for long-term average variance for SA40, Euro Stoxx 50, Nikkei 225 and S&P 500 spot and futures returns, respectively, exert influence on the current markets' volatility *before*, *during* and *after* the COVID-19 pandemic. The $A_{1,1}$, and $A_{2,2}$ which capture news about volatility from the previous periods, are significant for all the markets across time. This suggests that the markets' past volatility impacts the current volatility *before*, *during* and *after* the COVID-19 pandemic periods. Notice, however that the $A_{1,1}$, coefficients for the during-the-COVID-19 pandemic era is greater than the *before* and *after* the COVID-19 pandemic era. This indicates evidence of more spikey volatility than those of the *before* and *after* COVID-19 pandemic eras. Correspondingly, the $B_{1,1}$, and $B_{2,2}$, coefficients show evidence of volatility clustering in the SA40, Euro Stoxx 50, Nikkei 225 and S&P 500 spot and futures returns series in both *before*, *during* and *after* the COVID-19 pandemic periods. The

Table 4. Results of bivariate BEKK-GARCH (1,1) model for international equity futures and spot markets

Parameter	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500	SA 40	Euro Stoxx 50	Nikkei 225	S&P 500
	<i>Panel I. Before coronavirus</i>				<i>Panel II. During coronavirus</i>				<i>Panel III. After coronavirus</i>			
$C_{(1,1)}$	0.170	0.156	0.277	0.168	0.329	0.157	0.405	0.057	0.221	0.358	0.761	0.143
$C_{(2,1)}$	0.141	-0.142	-0.048	-0.113	0.238	0.065	0.104	-0.322	0.195	0.357	0.756	0.044
$C_{(2,2)}$	0.188	-0.079	0.164	0.139	-0.001	0.058	0.000	0.000	-0.141	-0.042	-0.000	0.000
$A_{(1,1)}$	0.299	-0.371	0.350	0.307	0.385	0.542	0.359	0.494	0.657	0.502	0.095	0.201
$A_{(1,2)}$	0.058	0.067	-0.053	-0.263	-0.175	-0.479	0.279	-0.088	0.358	-0.067	-0.438	-0.259
$A_{(2,1)}$	0.012	-0.021	-0.023	-0.067	0.018	-0.285	-0.210	0.227	-0.374	-0.057	-0.356	-0.037
$A_{(2,2)}$	0.180	0.072	0.135	-0.351	0.521	0.754	0.210	0.119	-0.271	0.530	0.175	0.037
$B_{(1,1)}$	0.937	0.927	0.913	0.930	0.901	0.858	0.618	0.552	0.332	0.818	-0.099	-0.723
$B_{(1,2)}$	-0.106	0.127	0.051	0.164	0.064	0.184	-0.657	0.670	0.371	-0.006	0.433	-0.640
$B_{(2,1)}$	0.054	-0.078	-0.030	-0.080	-0.017	0.099	0.588	-0.742	0.218	-0.052	-0.622	-0.652
$B_{(2,2)}$	0.971	0.967	0.953	0.874	0.862	0.781	0.677	0.552	0.137	0.765	0.239	0.695
<i>Panel IV. Wald test results for international equity futures and spot markets</i>												
1 → 2	123.85***	193.39***	11.95***	42.52***	6.24***	38.98***	100.01***	150.54***	30.57***	6.08**	7.18***	148.0***
2 → 1	51.91***	69.12***	6.17***	17.05***	0.52	20.52***	106.12***	150.52***	18.32***	4.14*	11.64***	122.3***
<i>Panel V. Robustness tests for the bivariate BEKK-GARCH (1,1) model</i>												
MvLM	13.99	2.28	3.59	0.38	7.53	0.84	3.68	0.37	4.51	4.19	11.11	7.95
10)	[0.17]	[0.99]	[0.96]	[1.00]	[0.67]	[0.99]	[0.96]	[1.00]	[0.92]	[0.93]	[0.34]	[0.63]
MvQ (10)	47.655	5.098	7.731	7.556	18.682	6.240	8.524	8.712	1.16	1.27	10.40	14.00
	[0.06]	[0.88]	[0.65]	[0.67]	[0.09]	[0.79]	[0.57]	[0.55]	[0.99]	[0.99]	[0.40]	[0.17]
Note(s): ***, ** and * refers to 1%, 5 and 10% levels of significance, respectively. [] refers to the p-value. $C_{(1,1)}$, $A_{(1,1)}$, and $B_{(1,1)}$, stand for the diagonal parameters of the equity spot returns conditional variance, and $C_{(2,2)}$, $A_{(2,2)}$, and $B_{(2,2)}$ refer to the diagonal parameters of the equity futures returns conditional variance. But the $A_{(1,2)}$, $A_{(2,1)}$, $B_{(1,2)}$, and $B_{(2,1)}$ represent the off-diagonal parameter, which measures volatility interaction. → indicates direction of volatility transmission. MvLM and MvQ are multivariate ARCH-LM and Ljung–Box Q-statistics for the null hypotheses of no ARCH effect and no autocorrelation in the BEKK-GARCH model's squared residuals and residuals, respectively. SIC selected lags 32 and 78 for the <i>during</i> coronavirus period and <i>before</i> coronavirus period, respectively												
Source(s): Table by author												

$B_{1,1}$ and $B_{2,2}$ coefficients for the COVID-19 era are lower than *before* and *after* the COVID-19 pandemic era.

This evidence of increased volatility during the COVID-19 pandemic aligns squarely with the extant literature. Existing empirical evidence on the nature of volatility clustering and persistence indicates that volatility is exacerbated during crisis periods. [Schwert \(2011\)](#) and [Chittedi \(2015\)](#) reported that crisis periods are associated with very high levels of volatility, especially in financial sector stocks. Recent COVID-19-related evidence suggests that most of the financial markets across the globe experienced a surge in volatility as well as the highest risk during COVID-19 when compared to other crises ([Emenike, 2021b](#); [Das et al., 2023](#)).

Evaluation of the statistical significance of the off-diagonal entries of matrices A and B (i.e. $A_{(1,2), (2,1)}$ and $B_{(1,2), (2,1)}$) using the Wald test is displayed in *Panel IV* of [Table 4](#). Notice that there is evidence of bidirectional volatility transmission between equity futures and spot returns of SA40, Euro Stoxx 50, Nikkei 225 and S&P 500, *before* the COVID-19 pandemic. These results provide evidence of the volatility interaction between equity futures and spot markets. But again, the magnitude of transmission is stronger from the spot market. The results also suggest the existence of interaction between the equity futures and spot markets in South Africa, the Eurozone, Japan, and the USA *before* COVID-19. The Wald test results for the COVID-19 pandemic era, displayed in *Panel IV* of [Table 4](#) did not change for the Euro Stoxx 50, Nikkei 225 and S&P 500. The markets exhibit bidirectional volatility interactions *during* the COVID-19 pandemic. The SA40, on the other hand, exhibits evidence of unidirectional volatility transmission from the spot market to the equity futures market. The Wald test results for the *after*-COVID-19 pandemic era are similar to the *before*-COVID-19 pandemic period for the SA40, the Euro Stoxx 50, Nikkei 225 and S&P 500. The markets exhibit bidirectional volatility interaction *after* the pandemic.

The results of the volatility interaction between equity futures and spot returns *before*, *during* and *after* the COVID-19 pandemic indicate that there was a sharp increase in volatility as well as in the magnitude of volatility interaction between the markets during the COVID-19 pandemic than was the case *before* and *after* the pandemic. This suggests that the financial markets were more interconnected and sensitive to shocks during the pandemic period.

These findings resemble the results of [Wats and Sikdar \(2022\)](#), who report, among others, that the spot market dominates the information dissemination process in emerging markets during crisis periods. The SA40 evince unidirectional volatility transmission and the other markets bidirectional volatility transmission *during* the COVID-19 pandemic period. The nature of volatility transmission between equity futures and spot markets has contagion implications. In the case of bidirectional volatility transmission, a shock in one of the markets will spread to the other markets, and vice versa. But in the case of unidirectional volatility transmission, a shock will only emanate from the risk giver, not the other way around. Hence, prediction of volatility from the spot market segment of the Euro Stoxx 50, Nikkei 225 and S&P 500 is crucial for mitigating portfolio risk in their futures segments, and vice versa ([Emenike, 2021a](#)). It is important for investors in these markets to closely monitor and analyse these interactions in order to make informed investment decisions and for effective risk management strategies.

In addition, the results of volatility transmission for South Africa do not seem to support the informed institutional investors' hypothesis and the trading cost hypothesis. While the former hypothesis posits that the derivatives market segment is dominated by informed institutional investors and, therefore, the equity futures market segment is expected to drive the price discovery process and transmit volatility to the spot market, the latter hypothesis predicts that the market with the lowest overall trading costs will react most quickly to new information ([Kim et al., 1999](#)). Contrary to the postulations of these two hypotheses, the SA40 spot market leads the equity futures market.

Overall, the results suggest that the spot market dominates the information dissemination process in the South African stock market, both *before* and *during* the COVID-19 pandemic. The results from the developed markets, on the other hand, suggest that the spot market has

more influence on the futures market during the COVID-19 pandemic period. This market behaviour provides support to the equity-led price discovery process during prolonged crisis periods such as the COVID-19 pandemic and seems to suggest that informed traders predominately traded on the spot market due to future uncertainties.

5. Conclusion

The interaction between equity spot and futures derivatives markets has implications for understanding the nature of information flows between the two market segments, portfolio risk management and the regulation of the markets. This study investigates the nature of the cointegrating relationship, causal dependence and volatility interaction between the equity spot and futures markets *before*, *during* and *after* the COVID-19 pandemic. In order to capture the COVID-19 pandemic-induced changes, the study period was split into *before*-COVID-19, *during*-COVID-19 and *after*-COVID-19 eras and analysed the South African, European, Japanese and USA markets using the Engle–Granger cointegration test, pair-wise Granger causality test and bivariate BEKK-GARCH model.

The results of the Engle–Granger cointegration test show evidence of a cointegrating relationship between equity spot and futures returns of the SA40, Euro Stoxx 50, S&P 500 and Nikkei 225 markets *before*, *during* and *after* the COVID-19 pandemic. The results of the pairwise Granger causality test for the period *before* the COVID-19 pandemic era show the existence of unidirectional causality from all the equity spot markets to the equity futures markets, except for the Nikkei 225, which appears segmented. The results of the *after*-COVID-19 pandemic era are similar to the *before*-COVID-19 pandemic results. However, results for the COVID-19 pandemic period show evidence of bidirectional causality between the equity spot and futures markets at the conventional significance levels, except for South Africa, which maintained the unidirectional causality from the equity spot to futures markets. There is therefore evidence of feedback interaction between the spot and futures markets of the Euro Stoxx 50, Nikkei 225 and S&P 500 during the COVID-19 pandemic, but the magnitude of causality is stronger from the equity spot market. It thus appears that the equity spot market has more influence than the equity futures market, in the majority of the results, in the short run. The equity futures market still plays a significant role in shaping market dynamics during times of crisis.

The results of the bivariate BEKK-GARCH model show evidence of significant own ARCH and GARCH parameters (diagonal parameters) for the SA40, Euro Stoxx 50, Nikkei 225 and S&P 500 indices for both *before*, *during*, and *after* the COVID-19 pandemic eras. The results illustrate that the markets' past volatility impacts the current volatility of spot and futures returns for all the periods, but the coefficients of the COVID-19 pandemic era are greater than those of the *before* and *after* COVID-19 pandemic era. Correspondingly, the GARCH coefficients for the COVID-19 era are lower than *before* and *after* the COVID-19 pandemic era. This suggests the existence of more spiky volatility than those of the pre- and post-COVID-19 pandemic era.

Results of the Wald test confirmed the existence of bidirectional volatility transmission between equity spot and futures returns of the SA40, Euro Stoxx 50, Nikkei 225, and S&P 500 *before*, *during*, and *after* the COVID-19 pandemic period, but the SA40 exhibits evidence of unidirectional volatility transmission from the spot market to the futures markets during the COVID-19 pandemic. These results provide evidence in support of shock and volatility interactions between equity spot and futures markets, but the magnitude of transmission is stronger from the spot to the futures market. The results also suggest the existence of full interaction between the spot and futures segments of all the markets *before*, *during* and *after* the COVID-19 pandemic, except for SA40, which had partial interaction during the COVID-19 pandemic period.

The findings of this study have important information flow implications for the equity spot and futures markets. Traders in the South African futures market, for example, could improve

equity futures pricing as well as minimise portfolio risk by vigilantly monitoring the price movements in the SA40 equity spot segment because of the unidirectional causal relationship and volatility transmission from the latter to the former. They should also consider the SA40 spot market when formulating hedging strategies in relation to the SA40 futures market. More so, speculators in the futures markets could also adjust their positions based on movements in the spot market because of the significant unidirectional causality and volatility transmission *before, during* and *after* the COVID-19 pandemic. Likewise, investors in the developed markets should also be vigilant, as the shock and volatility interaction between the equity spot and futures markets seems to be crisis-sensitive. This suggests that careful monitoring and risk management strategies are necessary to navigate through periods of market uncertainty.

The market regulation implications arise from the significant shock and volatility interactions among the equity spot and futures markets. Capital market policymakers should always monitor the nature, direction and magnitude of equity spot market volatility as an important variable in the formulation of capital market policies to minimise uncertainty and enhance stability. They should also be conscious of the crisis-sensitive nature of shock and volatility interactions between the equity spot and futures markets and use the information to make policies that will mitigate any possibility of contagion to other segments of the financial market.

Future research in this area of study should consider analysing intra-daily data rather than daily data, as it is considered more meaningful from a practical perspective. It will also be insightful to evaluate the effective strategies and techniques that would contain the impact of volatility transmission among equity spot and futures markets in crisis periods. In addition, this study can be extended by evaluating volatility interactions among other developing markets and international stock markets.

Notes

1. An equity futures contract is a type of derivative contract in which parties involved must transact shares of a specific company at a predetermined future date and price. Derivatives instruments, such as equity futures, are created and the market established to intensify the development of the financial system, enhance liquidity, serve as a tool for portfolio diversification and manage financial risk associated with the high volatility of asset prices.
2. The equity derivatives market is relatively new in sub-Saharan Africa. The earliest functional derivative market in sub-Saharan Africa is the Equity Derivative Division of the Johannesburg Stock Exchange (JSE), which has been in operation since 1990 (Adelegan, 2009). The JSE equity derivatives market monthly statistical reports show that, between April 1 and April 29, 2019, the market concluded 202,702 deals in 617,424 contracts valued at R223, 944,243,059. Another functional equity derivative market in sub-Saharan Africa is the Nairobi Securities Exchange (NSE) Derivatives Market (NEXT), which was registered in 2015 to offer equity index futures and single stock futures and started operation in January 2016 (Chidaushe, 2019). A very recent entrant into the equity derivation market is the Nigerian Exchange Limited (NGX), whose rulebook on the derivatives market became effective on April 14, 2022, having been approved in August 2019. The NGX started trading with 7-equity futures contracts.
3. Xue *et al.* (2014) show that the causal influence from the future market to the spot market was greater in the developed market than in the emerging markets.
4. The Europe Stoxx 50 equity futures and spot price indices, however, range from 15 August 2011 to 31 December 2021.
5. The South Africa 40 (SA40) is South Africa's leading stock market index, and it is composed of the 40 largest publicly traded South African companies on the Johannesburg Stock Exchange (JSE). The SA40 index futures is a derivative of the SA40 stock index.
6. The Euro Stoxx 50 is the Eurozone stock market index and comprises 50 stocks from 11 countries in the Eurozone. The index represents the largest and most liquid stocks in the Eurozone. The Euro Stoxx 50 index futures is a derivative of the Euro Stoxx 50 stock index.

7. The Nikkei 225 is the Tokyo Stock Exchange stock market index that measures the performance of 225 large, publicly owned companies in Japan. The Nikkei 225 index futures is a derivative of the Nikkei 225 stock index.
8. The Standard and Poor's 500 (S&P 500) is the stock market index that tracks the performance of the 500 largest companies listed on the United States of America's (USA) stock exchanges. The S&P 500 index futures is a derivative of the S&P 500 stock index.
9. Investing.com is a financial markets platform providing real-time data, quotes, charts, financial tools, breaking news and analysis across 250 exchanges around the world in 44 language editions. With more than 46 million monthly users and over 400 million sessions, [investing.com](https://www.investing.com) is one of the top three global financial websites according to both SimilarWeb and ALEXA. With over 300,000 financial instruments covered, [Investing.com](https://www.investing.com) offers unlimited access to cutting-edge financial market tools such as real-time quotes and alerts, customized portfolios, personal alerts, calendars, calculators and financial insights, completely free of charge. In addition to the global stock markets, [Investing.com](https://www.investing.com) also covers commodities, currencies, world indices, world currencies, bonds, funds and interest rates, ETF's futures and options.
10. The ABA research design is a single-case research design that has three phases. Phase A is the baseline condition (before COVID-19), Phase B is the treatment condition in which a manipulation is introduced (COVID-19) and Phase A is the return to the baseline condition (after COVID-19). This design allows for evaluation of the impact of COVID-19 by comparing the interaction between equity spot and futures markets *before and during* COVID-19 and after and during COVID-19. This research design reduces the possibility of a coincidental interaction, which may occur in the common A-B research design.
11. [Sarker et al. \(2023\)](#) note that the World Health Organization (WHO) declared the end of the pandemic phase of COVID-19 on May 5, 2023.

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