



## REINVESTIGATING THE CO-MOVEMENTS BETWEEN STOCK MARKET AND EXCHANGE RATES: AN AUGMENTED VECTOR AUTOREGRESSION ANALYSIS

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### ABSTRACT

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Empirical works on the stock market exchange rate nexus remain scanty in the managed floating exchange rate environment like Nigeria. Thus, our paper contributes to the scanty literature by analyzing how the COVID19 pandemic shapes the existing link in the oil-rich countries like Nigeria using a time series approach based on daily data spanning between 2017 and 2021. The paper investigates a Granger causality relationship in the specified VAR model by implementing the Toda and Yamamoto procedures while determining the direction of the causality through our impulse response analysis. Our findings show unidirectional causality from exchange rates to the stock market in the pandemic but no causality before the pandemic. This suggests that the exchange rate affects the performance of the Nigerian stock market in the pandemic period. Therefore, the Nigerian stock market and the exchange rate should not be considered as alternative strategies to mitigate risk during the crisis periods.

**Contribution/Originality:** This study provides the frontier analysis in examining how the COVID-19 crisis influences the existing relationship between the stock market and the foreign exchange market in the context of oil-rich countries like Nigeria. Our high-frequency datasets strengthen the analysis in capturing the daily transaction nature of these markets.

## 1. INTRODUCTION

Studying the behaviors of exchange rates has been receiving more attention since the Bretton Woods system failed. This leads to examining the stock market-exchange rate nexus using both macro and micro-data (Luzarraga-Goitia, Regúlez-Castillo, & Rodríguez-Castellanos, 2021). This relationship provides critical insights for economic policy-makers in stimulating economic development; for investors in exploring arbitrage to obtain profits, and for business managers in choosing optimal hedging tools and portfolio selections. The relationship would also support financial regulators in managing their floating exchange rate environments. This usefulness has motivated academic research in exploring an interdependence between the stock market and the foreign exchange market.

The research analyzing this financial market interdependence is built on two main theories namely, The Flow or Traditional Theory, and The Portfolio Balance Theory. The flow theory believes that the movements in exchange rates lead to stock market movements (Dornbusch & Fischer, 1980; Fleming, 1962; Mundell, 1963) while the portfolio balance theory associates exchange rate volatility with the stock market conditions (Branson, 1972; Branson & Henderson, 1985).

However, the absence of theoretical consensus on the link manifests stronger in the results of empirical literature beyond the relationship and the direction including, an inconclusion of their existence (Luzarraga-Goitia et al., 2021). Few empirical studies such as Kollias, Mylonidis, and Paleologou (2012); Kollias, Papadamou, and Siriopoulos (2016); Tsagkanos and Siriopoulos (2013), reinforced the appropriateness of the portfolio balance approach in understanding the link between stock markets and exchange rates, especially in the crisis periods. Furthermore, these empirical studies focused on developed economies characterized by floating exchange rate system. To the best of our knowledge, little research has been carried out in an environment of managed floating exchange rates. Thus, our study extends the existing empirical literature through the following channels. First, our study focuses on the Nigerian environment where managed floating exchange rate is being practiced. Second, we use Granger causality tests while accounting for the effect of the COVID19 pandemic. In addition, our method follows the work of Toda and Yamamoto (1995) to address the issue of non-stationarity and no co-integration established in the literature (Luzarraga-Goitia et al., 2021). Third, we employ high frequent and most recent daily data in analyzing the Granger causality. Our highly frequent datasets fill one of the potential research gaps identified in the recent literature (Luzarraga-Goitia et al., 2021).

The rest of our paper is organized as follows: Section 2 reviews the related empirical studies while Section 3 shows the methodology and presents the empirical results. Section 4 discusses the empirical results. Policy implications and conclusions are provided in Section 5.

## 2. RELATED EMPIRICAL LITERATURE

The empirical studies on the link between exchange rates and stock markets could be traced to the 1980s with the pioneering work of Aggarwal (1981) and his followers such as Solnik (1987); Soenen and Hennigar (1988); Jorion (1990). These early studies applied correlation and/or regression approaches to investigate the exchange rate-stock market nexus. Their works were extended by Bahmani-Oskooee and Sohrabian (1992) through an investigation of the integration and co-integration properties of the two variables in the context of the US economy. Unlike the pioneering literature, they found that dollar depreciation contributes to a rise in exports and the concerned companies' returns. Our paper extends Bahmani-Oskooee and Sohrabian (1992) techniques by accounting for the COVID19 pandemic effect on the two-variable series (stock market and exchange rate) while examining their integration and co-integration properties. Subsequent empirical works in the 1990s extended the existing scope beyond the US economy to Asian economies (Abdalla & Murinde, 1997), as well as developed and emerging economies (Abdalla & Murinde, 1997). While Abdalla and Murinde (1997) report a unidirectional causality between exchange rates and stock markets in India, Korea, and Pakistan before the 1997 Asian financial crisis; Ajaji, Friedman, and Mehdiian (1998) findings reveal the opposite in the context of developed economies but inconsistent causal relationships in the emerging countries before the 1997 Asian financial crisis. The inconclusive evidence in the literature strengthens the need for our paper to fill the existing gap.

Studies (Granger, Huangb, & Yang, 2000; Kollias et al., 2012; Lean, Halim, & Wong, 2005; Luzarraga-Goitia et al., 2021; Ooi, Wafa, Lajuni, & Ghazali, 2009; Pan, Fok, & Liu, 2007) from the 2000s, paid significant attention in understanding the effect of the crises on the dynamics between exchange rates and stock markets. For instance, Ooi et al. (2009) extended the previous literature to examine the influence of the Asian crisis in the case of Malaysia and Thailand. Their findings reveal that the stock market Granger affects the exchange rate after the crisis in Malaysia, in line with the literature (Granger et al., 2000; Lean et al., 2005; Pan et al., 2007), while this causality exists before and after the crisis for Thailand. We thus extend these studies by examining the causality before and during the pandemic crisis rather than after the crisis in the literature. On the other hand, the impact of the 2007/2009 Global Financial crisis on the exchange rate-stock market nexus is also examined in the literature (Agrawal, Srivastav, & Srivatava, 2010; Kollias et al., 2012). These studies find that stock markets significantly influence the exchange rate in the crisis period. This significant strength is also established among stock markets themselves in the empirical works (Bhatti & Nguyen, 2012; Luo & Bhatti, 2019). Another stream of literature (Caporale, Hunter, & Menla Ali,

2014; Inci & Lee, 2014; Kollias et al., 2016; Sui & Sun, 2016; Wong & Li, 2010) further analyzes the stock market returns and exchange rate volatility in different crisis periods. These studies reinforce the stronger effect between the two variables after the crisis. To the best of our knowledge, no study has examined the impact of the COVID 19 crisis on the relationship between exchange rate and stock market. Thus, our paper extends the literature to examine the pandemic effect on the stock market-exchange rates nexus in the context of Nigerian economy.

### 3. METHODOLOGY AND DATA

#### 3.1. Hypothesis Formulation

As the existing empirical literature (Granger et al., 2000) finds a great significant link between the exchange rate and the stock market during the crisis periods, we thus propose the following hypothesis:

*The causality relationship between bilateral exchange rates and the stock market is expected to be weak in the pre-COVID 19 pandemic crisis and robust in the pandemic periods in the context of Nigeria.*

In line with the assumption indicated in the above-stated hypothesis, their signs should be negative for export-heavy countries or positive for the import-heavy country (Luzarraga-Goitia et al., 2021). On the other hand, the direction of causality remains an ongoing debate in the literature. For instance, some empirical studies such as Kollias et al. (2016); Tsagkanos and Siriopoulos (2013) reveal a strong unidirectional causality from stock markets to exchange rates in the crisis periods; while others (Pan et al., 2007) find that dynamics between stock markets and exchange rates may vary according to periods and other factors such as economic characteristics. Thus, we test the above hypothesis by following the approach of Luzarraga-Goitia et al. (2021) to examine the Granger causality between the bilateral exchange rate and the stock market in a bivariate Autoregressive Vector (VAR) setting.

#### 3.2. Sample Periods and Data

To test our hypothesis, we employ daily data spanning from 31 July 2017 to 30 April 2021 in conducting the empirical investigation. Then, we assess the impact of the pandemic crisis by splitting our entire sample into two sub-sample periods: from 31 July 2017 to 31 December 2019, before the pandemic crisis, and from 1 January 2020 to 30 April 2021 during the pandemic period. The latter sub-sample period is based on World Health Organization (WHO) which names Coronavirus a pandemic.

The data used in the analysis are obtained from Thomson Reuters' database while the sample period is influenced by the data availability. The spot exchange rate is measured as the official bid exchange rate of Naira per US Dollar while the stock price is measured as Nigeria's all-share index. All the series are transformed into decimal logarithms as well as daily logarithmic differences (where is appropriate). Table 1 displays summary statistics of all-share indexes (ASI) and exchange rate (NGN/USD). As reported in the table, significant variations in the mean of the two variables exist between the pre-pandemic sub-sample periods and the pandemic sub-sample periods. For instance, the average exchange rate during the pandemic period exceeds its counterpart rate by about 25 Naira (the crisis leads to a 7% depreciation of the Nigerian currency against the US dollar on average). This indicates that more Nigerian currency is used to exchange for one US dollar during the pandemic crisis compared to the non-pandemic periods. On the other hand, the average all share index in Nigeria significantly falls from 33,782.18 to 30,339.94 due to the pandemic crisis. Another important observation is that the maximum exchange rate before the pandemic is slightly above the minimum exchange rate during the pandemic (see Table 1).

#### 3.3. Identification of Causality Relationships

We then utilize the obtained dataset to check whether there is Granger causality between the stock market and exchange rate using a VAR model with appropriate tests to establish and show the direction of this relationship.

To avoid spurious regression results, we first perform the stationarity test on each variable series. We then implement Granger causality procedures proposed by Toda and Yamamoto (1995), which are robust to different

orders of integration as well as the absence of co-integration (Luzarraga-Goitia et al., 2021).

Table 1. Summary statistics.

Panel A: Full sample (2017-2021)								
Variables	Mean	Std Dev.	Median	Min.	Max.	Skewness	Kurtosis	Obs.
ASI	32,557.04	5,981.46	31,846.02	20,669.38	45,092.83	0.14	1.88	930
NGN/USD	369.74	14.57	362.50	349.60	411.64	1.48	4.10	930
Panel B: Pre-COVID19 sub-sample period (2017-2019)								
ASI	33,782.18	5,169.76	32,466.27	26,092.82	45,092.83	0.30	1.98	599
NGN/USD	361.04	1.66	361.00	349.60	366.63	-0.14	6.07	599
Panel C: COVID19 sub-sample period (2020-2021)								
ASI	30,339.94	6,680.85	28,067.09	20,669.38	42,412.66	0.47	1.66	331
NGN/USD	385.47	14.39	385.00	360.00	411.64	0.17	2.47	331

### 3.4. Unit Roots

As unit root tests suggest the order of integration of the concerned variable series, we employ the augmented Dickey-Fuller test (ADF) (Cheung & Lai, 1995; Dickey & Fuller, 1981) in determining their order of integration. In addition, we implement the ADF test with the assumption of either a constant or linear trend for each variable. Table 2 reports the ADF results for the stock market and the bilateral exchange rates of the Naira against the U.S. Dollar using their log-transformed series in both levels and first differences for the following cases: full sample periods, pre-pandemic sub-sample periods, and pandemic sub-sample periods.

As observed in the table, we conclude that the null hypothesis of non-stationarity is not rejected at the 5% significant level in their level except for that of the Naira against the U.S. Dollar for the 2017-2019 sub-sample period. However, in the first difference tests, all the series are stationary in both full sample periods and two sub-sample periods. Thus, we find mixed evidence of stationarity either at zero  $I(0)$  or first-order integration  $I(1)$ . This suggests the use of maximum order of integration  $d_{max}$  of 1 as required in the Toda and Yamamoto procedure. Therefore, we carry out our causality analysis taking  $d_{max} = 1$ , in the next subsection.

Table 2. Results of stationarity ADF test.

Variables	ADF	
	Constant	Constant and Trend
Levels(log): full sample 2017-2021		
ASI	-0.983(20)	-0.325(20)
NGN/USD	0.720(20)	-1.443(20)
Diff. (log): 2017-2021		
ASI	-14.185(20) **	-14.279(20) **
NGN/USD	-13.941(20) **	-14.106(20) **
Levels(log): Pre COVID 19 2017-2019		
ASI	-0.983(20)	-2.241(18)
NGN/USD	-3.380(18) *	-4.517(18) **
Diff.(log): 2017-2019		
ASI	-12.510(18) **	-12.519(18) **
NGN/USD	-13.689(18) **	-13.761(18) **
Levels (log): COVID19 2020-2021		
ASI	-12.510(18) **	-12.519(18) **
NGN/USD	-13.689(18) **	-13.761(18) **
Diff. (log): 2020-2021		
ASI	-8.826(16) **	-8.900(16) **
NGN/USD	-15.874(16) **	-15.850(16) **

Notes: the null hypothesis is that the series has a unit root in the ADF (Dickey & Fuller, 1979). ASI denotes Nigeria's All Share Index. \*, \*\* denotes 5% and 1% significance level. In parentheses: the optimum number of lags based on the Akaike (1974) information criterion.

### 3.5. Causality Tests

#### 3.5.1. Procedure

The non-stationarity of two series found in the literature (Andrews, 1987; Toda & Phillips, 1993) leads to a possible solution provided by Toda and Yamamoto (1995). The authors address the problem by implementing the Granger causality using the standard Wald test while specifying a VAR level with augmented lags. Their procedures allow the causality analysis regardless of stationarity order and cointegration results. To implement The Toda and Yamamoto Procedure, the following steps are required: The first step is to identify the maximum order of integration  $d_{max}$  of the series; the next step is to include  $d_{max}$  in the VAR(p) additional lags after establishing the optimal number of lags P using standard criteria such as that of Akaike (1974). Then, we perform their procedures by estimating the following lag-augmented VAR[VAR(p+ $d_{max}$ )] models:

$$ST_t = \alpha_1 + \sum_{i=1}^{p+d_{max}} \beta_{1i} ST_{t-i} + \sum_{j=1}^{p+d_{max}} \gamma_{1j} EX_{t-j} + u_{1t} \quad (1)$$

$$EX_t = \alpha_2 + \sum_{i=1}^{p+d_{max}} \beta_{2i} EX_{t-i} + \sum_{j=1}^{p+d_{max}} \gamma_{2j} ST_{t-j} + u_{2t} \quad (2)$$

Where  $ST_t$  denotes the representative index of the stock market and  $EX_t$  is the exchange rate.

We then apply the Wald statistic to test whether the exchange rates Granger cause stock market changes, under the null hypothesis of all the p-lags of the exchange rate variable ( $EX_{t-j}$ ) coefficients are jointly equal to zero. Rejection of the null hypothesis suggests that exchange rates Granger cause stock market changes while failure to reject the null hypothesis implies that exchange rate movement does not contribute to the stock market fluctuations. The same procedure is performed in Equation 2, to determine whether the stock market ( $MV_{t-j}$ ) Granger causes exchange rates. If the null hypothesis is rejected in Equations 1 and 2, this suggests a bidirectional causality between exchange rates and the stock market.

In the above-specified equations, we state the hypothesis in terms of VAR as follows:

*H1: in Equation 2, the p coefficients of the exchange rate lags are expected to be jointly significant in the pandemic.*

*H2: in Equation 2, the p coefficients of the stock market index lags are assumed to be jointly significant in the pandemic.*

#### 3.5.2. Empirical Results

Table 3 provides the results of Granger causality tests specified in the previous subsection. As reported in the table, we find no evidence of causality from the exchange rate to the stock market at 5% significance for the pre-COVID19 sub-period. However, in both the full sample period and the pandemic sub-sample, our finding shows significant evidence of Granger causality from the bilateral exchange rate towards the stock market. The degree of significance is stronger in the pandemic, reinforcing the idea of a robust causal relationship in the crisis period. Therefore, our result supports H1. In contrast, we refute H2 as the Granger causality from the stock market to the exchange rate is not significant at the 5% significance level in both the COVID19 sub-period and the pre-COVID19 sub-period.

### 3.6. Impulse-Response Analysis

We then conduct the impulse-response analysis to determine the signs of the directions in the established causal relationship for the pandemic sub-period. The result of the analysis is graphically presented in Figure 1. As observed in the figure, the stock market response to a shock in the exchange rate (the NGN/USD) is positive for the first four days but turns nearly zero on the fifth day. After the fifth day, the stock market reactions remain positive. Therefore, we believe that this result confirms that Nigeria is an import-heavy country when the country's trading partner is the United States of America (U.S.A).

Table 3. Results of Granger causality tests.

	<i>p</i>	<i>P</i> + <i>d</i> <sub>max</sub>	<i>ER</i> → <i>ASI</i>	<i>F</i>	<i>P</i> value	<i>ASI</i> → <i>ER</i>	<i>F</i>	<i>P</i> value
<i>d</i> <sub>max</sub> = 1	Full sample 2017-2021							
Log ASI/ LogNGN/USD	6	7	Yes	3.2	0.004	No	1.431	0.20
Pre-COVID19 2017-2019								
Log ASI/ LogNGN/USD	6	7	No	0.723	0.631	No	1.251	0.28
COVID19 2020-2021								
Log ASI/ LogNGN/USD	6	7	Yes	4.543	0.000	No	2.061	0.06

Notes: ASI denotes Nigeria's All Share Index and ER denotes Exchange Rate.

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

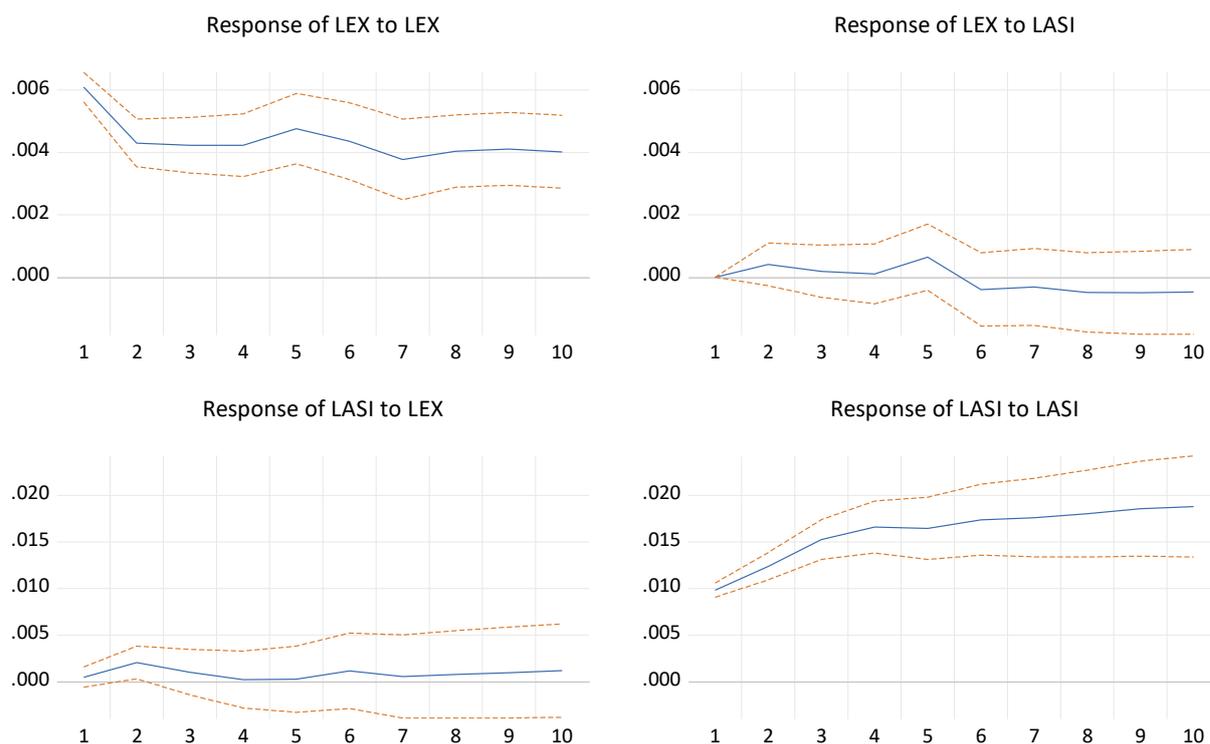


Figure 1. The impulse response of the stock market and exchange rates.

Note: LASI denotes the log of the stock market index; LEX is the log of the bilateral exchange rate.

#### 4. DISCUSSION OF RESULTS

Our results reveal a significant causal relationship in the pandemic crisis. The impulse-response analysis reinforces the relationship with a positive direction showing the import-heavy nature of Nigeria in relation to the U.S. Dollar considered. Thus, we fail to reject our research hypothesis H1. However, we find an insignificant causal relationship between the stock market and the exchange rate in the COVID19 sub-period as well as in the pre-COVID19 period. Therefore, we reject this latter hypothesis H1.

Our findings are consistent with those of previous studies on the Asian crisis (Pan et al., 2007). Therefore, we reinforce the traditional or flow view on the relationship between exchange rate and the stock market. On the other hand, our result does not establish the Granger causality running from the stock market to the exchange rate as postulated by the portfolio balance approach (Branson & Henderson, 1985).

Our impulse response analysis supports the expected positive causality sign from the NGN/USD rate towards the stock market during the pandemic due to Nigeria's heavy import dependence on the U.S.A.

## 5. CONCLUSION

Our study fills the research gaps identified in the literature by identifying and analyzing the causal relationship between the stock market and bilateral exchange rates in the context of managed floating environment like Nigeria. This makes our research unique from the previous studies whose focus is on floating and fixed exchange rates outside the African landscape. We draw the following conclusions based on our findings: first, no significant causal relationship exists between the exchange rate and the stock market before the pandemic crisis. Second, unidirectional causality from the bilateral exchange rate to the stock market is established in the COVID19 crisis. This suggests that the exchange rate risk influences the performance of the Nigerian stock market. Third, our impulse response analysis suggests a positive direction of this relationship, thus indicating Nigeria's import heavy dependence on the U.S.A.

In line with our findings, we suggest the following recommendations:

- Nigerian capital market and the exchange rate should not be considered as alternative strategies to mitigate risk in the crisis periods rather than the exchange rate poses risk to the Nigerian stock market.
- Businesses should effectively manage exchange-rate risk in the crisis period to foster their profitability and competitiveness.

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**Authors' Contributions:** Both authors contributed equally to the conception and design of the study.

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