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Causality Evidence of Exchange Rate - Stock Price Relation in Nigeria: Symmetric and Asymmetric Approach

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Abstract: Foreign exchanges and stocks are the two most traded financial assets in the world. The causality between their prices remains subject of research. The contention often follows that it is the exchange rate that drives stock price, according to the flow-oriented models or that the stock price drives exchange rates based on the stock-oriented models. I used available data from Nigeria to explore the Granger causality between them based on the symmetric approach, from Toda-Yamamoto (1995) and the asymmetric approach for handling connectedness for ergodic variables with deterministic trends, from Hatemi-J (2012). The test completed identifies that the two considered series are integrated. The results from the symmetric method recognise causality from exchange rate to the stock price with no potential Granger-causal feedback. I transform the integrated series into negative and positive cumulative fragments, and complete the asymmetric test using the Wald statistic to verify the likelihood of lopsided causality. The results identify that allowing for asymmetry, and in particular, positive shocks in the exchange rate can cause a positive shock in share price, and not vice versa. Also, negative shocks in the exchange rate would not cause a negative shock in share price. This implies that any depreciation or devaluation of the naira would motivate investors to increase their participation in the stock market. This finding has implication to the different stakeholders, including government, regulators and markets traders, in the Nigerian context.

Keywords: Asymmetric causality; Granger causality; Symmetric causality; Negative cumulative component; Positive cumulative component

JEL Classification: H16; F31; C2

1. Introduction

For decade long, theoretical postulations have examined the interconnection between asset prices (Ross, 1976; Branson, Halttumen & Masson, 1977; Dornbusch & Fisher, 1980). The flow-oriented models argue that exchange rates determine stock prices

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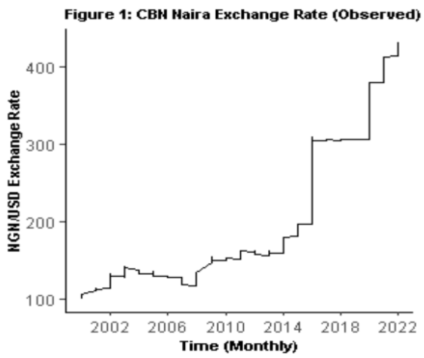
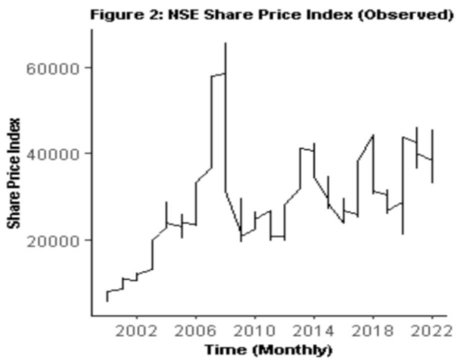
(Dornbusch & Fisher, 1980; Mwanza, 2014; Bahmani-Oskooee & Saha, 2016), whereas the stock-oriented models suggest that stock prices determine exchange rates (Frankel, 1983; Gudmundsson, 2014; Bahmani-Oskooee & Saha, 2018). The relationship between both asset prices has implications for policy formulations. For instance, if the exchange rates drive stock prices, then policies that mitigate exchange rates instability would stabilize stock prices and their volatility. Equally, if the stock prices influence exchange rates, implementing policies to stabilise stock prices might simultaneously control excessive fluctuation of the exchange rates.

This study intends to establish the dynamics of causality between naira-dollar's exchange rate of the Central Bank of Nigeria (CBN) and the all-share price index (ASI), from the Nigeria Exchange Group (NXG). Nigeria concurrently witnesses fluctuations in both stock prices and exchange rates. Official reports show that the ASI increases by 74.73%, from 33189.3 in 2006 to 57990.2 in 2007. The 2008 global financial crisis causes concurrent domestic recession leading to a drop in the ASI from 57990.2 in 2007 to 26874.62 in December 2016, representing a 115.78% (Nkoro & Uko, 2016). In the same vein, the exchange rates remain very volatile (Ajao & Igbekoyi, 2013; Hassan, Abubakar, & Dantama, 2017; Gbadebo, 2023). The exchange rate, which averages NGN196.92/$ in June 2015 fell low to NGN ₦309.73/$ in August 2016 and ₦305.54/$1 in May 2017, representing a 55.16% fall in value. The naira depreciated by 122% against the dollar, from an average of NGN196.5/USD in 2015 to NGN436.78/USD in 2022. Figure 1 (2) depicts the time series plot for the actual exchange rate (share price index).

The paper resolves the issue around whether stock prices influence the exchange rates or exchange rates influence the stock prices, as well as establishes the potential asymmetric connection between the two assets prices. Research makes assumptions on the relationship to test if a variable precedes another in addressing causality (Granger, 1969; Toda & Yamamoto, 1995; Hatemi-J, 2012). Khan and Ali (2015) show bidirectional connection between rupee volatility and stock price in Pakistan. Sikhosana and Aye (2018) find a bidirectional asymmetric effects between the real exchange rate and stock return in South Africa. Mlambo e al. (2013) assert that fluctuations in the exchange rate can affect the performance of the stock markets. For Nigeria, Tule et al. (2018) show unidirectional transmission effect from the stock price exchange rate without a breakpoints consideration. Zubair (2013) finds no connection between naira exchange rate and stock price. Tule et al. (2018) identify a bidirectional (unidirectional) pattern transmission mechanism from stocks to exchange rate with (without) breakpoints effect. Manasseh et al. (2019) show bidirectional volatility transmission, supposing past innovations in stock price impinges effect on future volatility in the exchange rates.





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I use the stock price and the exchange rate to determine the Granger causality between the variables from the Toda-Yamamoto (1995)'s symmetric approach and the Hatemi-J (2012)'s asymmetric causality. The finding from the symmetric causality reveals causal effects from the exchange rate to stock price with no potential feedback. The asymmetric causality identifies those positive shocks in the exchange rate can cause a positive shock in share price, and negative shocks in the exchange rate would not cause a negative shock in share price. This implies that any depreciation or devaluation of the naira can motivate investors to increase participations in the stock market. This has vital implications to different stakeholders in the Nigerian markets. The remainder parts include: Section 2, 3, 4 and 5, for the literature, methodology, results, and conclusions.

2. Literature

Three major theoretical postulations propose the interactions between the stocks and the foreign exchange markets – the arbitrage pricing model (APM), flow-oriented model and stock-oriented (Ross, 1976; Dornbusch & Fisher, 1980; Frankel, 1983). The APM, from Ross (1976), supposes that expected gains from securities is dependence on economic factors. Because exchange rate and stock markets are two fundamental global markets, the exchange rate-stock price nexus is indispensable for macroeconomic interdependence. The exchange rate is identified macroeconomic factor that drives the stock prices via path of monetary shocks. The volatility in economic and financial settings are conceived to exacerbate the interactions between exchange rate and the stock market, and most times the fluctuations are considered heterogeneous (Zhu et al., 2022). Tule et al. (2018) show how factors including severe pressure oil prices and extreme volatility of the naira-dollar exchange affect the stock prices. Increase in the domestic interest rates, or interest rate differentials would motivate foreign capital inflows, thus, causes stock price to increase and result in currency appreciation (Bahmani-Oskooee & Saha, 2018).

Zhu et al. (2022) use wavelet decomposition to recover tim-frequency effect, and find asymmetric effects of exchange rate and oil price on stock returns of BRICS, from 2009–2020. Positive (negative) shocks of oil have a much more impact on the bull (bear) market, whilst the shocks have a greater impact on a market. Wong (2022) shows that real- output and interest rates have significant impact on stock price. Chen and Li (2023) use the capital APM framework which links consumption to exchange rate variations by the exchange rate elasticity of aggregate consumption (EREAC), and find correlation directionality between exchange rate and stock return. The EREAC (either below or above its threshold) inversely affects the currency risk price.

The flow-oriented (i.e., goods market) approach offers that fluctuation in stock prices are largely influence by currency movements. The approach theorized on the macroeconomic view that because share prices characterize discounted present value of expected cash flows, any factor that affect the cash flow reflects in stock price. The flow-oriented model shows that the causal direction is from exchange rates to stock prices. The currency movements affect competitiveness and balance of trade, real output, and in turn affects firms' cash flows causing movements in stock price. Bahmani-Oskooee and Saha (2016) show that though competitiveness holds amongst export-oriented businesses, but exchange rate fluctuations impinge opposite effects on importing firms. After depreciation, stock prices decrease (increase) when the economy has less (more) exporting firms relative to importing ones, whereas after appreciation, stock prices decrease (increase) when the country has more (less) relative exporting firms.

The stock-oriented model (portfolio balance approach), from Frankel (1983), captures the relationship in reverse causality and takes into account international capital movements neglected by the flow-oriented model. The causation runs from stock prices to exchange rates and posits a positive relationship between the two variables. The models note that stock price causes drive the exchange rate via the capital account transactions. A rise in the stock price attracts capital flows, which in turn cause increase demand for the domestic currency and, therefore make the exchange rate to appreciate. The extent at which stock-oriented models explain currency movements is a function of stock market liquidity (Gudmundsson, 2014). As investors substitute foreign securities for domestic assets, there will be increase in capital inflows and demand for local currency, ultimately resulting in currency appreciation (Gudmundsson, 2014; Mwanza, 2014). Bahmani-Oskooee and Saha (2018) contend that stock prices drive the exchange rates via wealth and expectation effects transmissions. Rise in stock price increase investors' wealth, leading to increase in appreciation of the exchange rate.

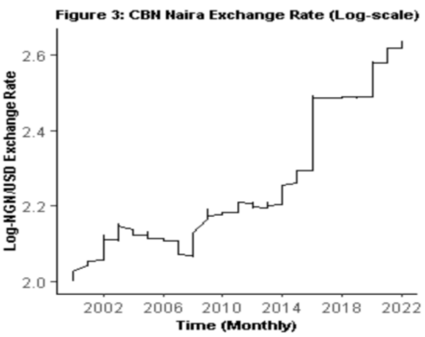
The connections between exchange rates and stock prices have motivate different empirical studies. Ajayi and Mougoue (1996) use the error correction model (ECM) to examine the intertemporal relations for the two variables in eight economies and reveal significant short- and long-run feedbacks between the asset prices. The short (long) run evidence identifies that increase in stock price has a negative (positive) impacts on naira values. Hatemi-J and Irandoust (2002) use the Toda and Yamamoto (1995)'s symmetric test to examine multivariate Granger causal relation between both variables based on the intertemporal VAR procedure. The evidence identifies the causality as unidirectional, running from the stock price to the effective exchange rate of the Swedish krona. Phylaktis and Ravazzolo (2005) apply the cointegration and Granger causality tests the dynamics for selected Pacific Basin countries during 1980–1998. The evidence reveals that both stock price and exchange rate are positively linked and that the US markets act as the conduit for these connections.

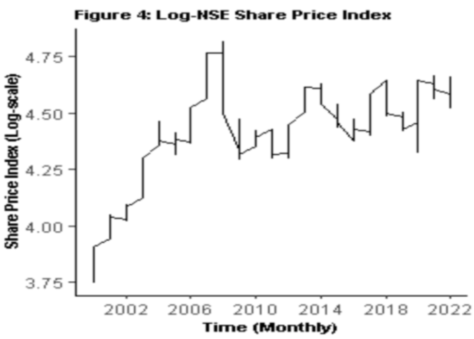
Suriani et al. (2015) investigate the relationship based on monthly data for Pakistan using KSE-100 index (stock price) and the Pak Rupee per Dollar (Rs/US$) and find that both exchange rate and stock price are independent. Özbey et al. (2016) use the GARCH to explore the relationship between Dollar-Turkish Lira (USD/TRY) and BIST-100 of Istanbul Stock Exchange and reveal that increase in the USD/TRY-rate reduces expected return, but increases riskiness of the BIST-100. Yang (2017) explore both short- and long run interaction and the causality between exchange rates and stock prices in four Asia-Pacific countries. The study shows that impacts of monetary shocks to stock price are contemporaneous, and an exchange rate shock results in instantaneous change in stock price, however, the stock price shock only drives gradual deviations in the exchange rate of the four countries. Nusair and Olson (2022) examine G7 countries' data confirms that causality runs from stock prices to exchange rates in almost all countries. Hashmi et al. (2022) use Pakistan quarterly data during 2000:01–2019:04 and finds that how oil and exchange rates (stock prices) affect stock prices (exchange rate) varies (does not varies) across for normal, bearish, and bullish market states. Wong (2022) uses NARDL to inspects the effects of asymmetric real exchange rates and exchange rates on the real stock prices in selected economies and find that the asymmetric real exchange rate has more significant impact on stock price.

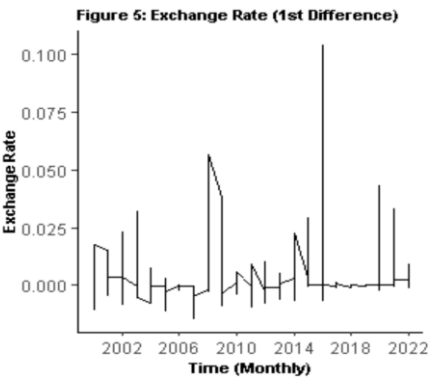
On the domestic from some investigations have been made (Zubair, 2013; Tule et al., 2018; Manasseh et al., 2019). Zubair (2013) finds no direct linkage between ASI and naira before and during the crisis based on evidence from period 2001–2011, suggesting that the market is inefficient. Tule et al. (2018) use the multivariate GARCH and suggest presence of a transmission channel between the stock returns and the naira exchange rate. The shock identifies a unidirectional transmission mechanism from stocks to exchange rate without breakpoints but for considered breakpoints a feedback effect (bidirectional pattern) was identified across the efficient markets. Manasseh et al. (2019) apply the multivariate VAR-GARCH model to examined the interactions, from 2000:01–2014:10, and the evidence shows stable long-term relationship and a significant unidirectional spillover, from stocks to the exchange rate market but not the reverse. The variance equation evidence shows bidirectional volatility transmissions, thus supposing that past innovations in stock price impinges effect on future volatility in exchange rate market, and vice versa. Notably, none of these studies have considered the potentials of asymmetric relations, therefore this study fills this gap.

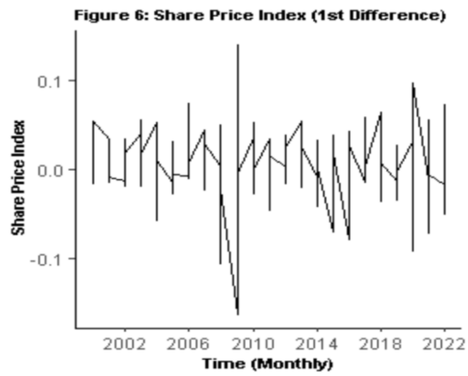
3. Methods

I use monthly series for naira-dollar rate, from the CBN, and all-share price index, from the NXG, for the periods covering 2000M04–2022M09. The periods are selected due to availability of complete data for the two considered series. To ensure the estimators are less likely sensitive to individual measurement unit as well as minimizes possible inherent heteroscedasticity in the autoregression, I scaled the series based on log-normalized procedure (Mills, 2019, Gbadebo 2023). Figure 3 (4) shows the time series plot for the log-scaled exchange rate (share price index). The exchange rate series (actual and log-scaled) are drifted, upward trended, and negatively skewed, supposing the tendency for nonstationary. Figure 5 (and 6) is the plot for the first difference of exchange rate (and share price).









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I perform the *preliminary evaluation* to establish the basic deterministic and stochastic information related to the considered variables according to the features reveal by the plots. The stochastic characterization shows the property of the data generating process for the two variables, denoted $x_{i,t}$. I use two different tests − the Augmented-Dickey-Fuller (ADF) and the Phillip-Perron (PP) – to establish the stationarity position. The process would identify exchange rate and share price as $I(d)$ for d's differenced order before stationary is attained, where *d* is the integration order). The ADF uses (1) to verify stationarity.

$$x_t = a_0 + \varphi x_{t-1} + \sum_{i=1}^{p-1} \delta_i \, \Delta x_{t-i} \; + \Omega_t; \; i = 1, 2, \ldots, p-1 \quad (1)$$

$\delta_i = -\sum_{j=i+1}^{p-1} \varphi_j$, where, a_0, Ω_t and p, are drift, Gaussian noise and lag-length, respectively. The ADF test is completed using a null of non-stationarity ($H_0 \colon \varphi = 1$) and an alternative ($H_1 \colon \varphi > 1$). ADF-test statistics (τ_μ) is:

$$\tau_\mu = \; \hat{\varphi}_T - 1/se(\hat{\varphi}_T) \quad (2)$$

Where $se(\hat{\varphi}_T)$ is $\hat{\varphi}_T'$'s standard error], computed from ordinary least squares.

The PP-test ensures a_t is white noise, hence, accommodates autocorrelation. The test allows for heterogeneity and augments (1), by redefining φ in (1) as $\varphi = \sum_{i=1}^{p} \varphi_j$, and $\delta_j = -\sum_{j=i+1}^{p-1} \varphi_j$ (for $i = 1, 2, \ldots, p-1, k = p-1$).

PP-test statistics (τ_{PP}) is:

$$\tau_{PP} \; = \; \tau_\mu(\hat{\sigma}_\mu/\hat{\sigma}_\mu) - 0.5(\hat{\sigma}_t^2 - \hat{\sigma}_0^2)/\Sigma_\ell \quad (2a)$$

With: $\hat{\sigma}_0^2 = T^{-1} \sum_{=1}^{T} \hat{a}_t^2$;

$$\hat{\sigma}_\ell^2 = \hat{\sigma}_0^2 + 2T^{-1} \sum_{j=1}^{\ell} w_j \, (\ell) \sum_{t=j+1}^{T} \hat{a}_t \, \hat{a}_{t-j})$$

$$\Sigma_\ell^2 = T^{-2} \hat{\sigma}_\ell^2 \sum_{l=2}^{T} (x_{t-1} - 1 - \overline{x}_{-1})^2$$

Where, $\overline{x}_{-1} = (T-1)^1 \sum_{t=1}^{T-1} x_t$ and $\hat{\sigma}$ is a consistent estimator of the long-run variance which employs (a kernel function $[w_j(\ell)]$ as weight of sample autocovariances. The test checks the null $\varphi = 1$ (nonstationary) against the alternative, $\varphi > 1$.

Table 1 shows the statistics and stochastics' properties for variable's log-scaled series. Clearly, the differenced series are stationary. Both series identify high swings and validate sign for nonstationary. The unit root tests is applied, and the outcomes, according to the ADF and PP tests, identified the log-standardized exchange rate and share price as non-stationary but integrated and differenced stationary (I(1)).

Both markets are precarious, and traded assets prices is not surprisingly expected to experience run-up, spikes and resistance at different times. The correlation between both variables (0.547) is positive, moderate and significant, suggesting normal exchange rate-stock price co-movement. This supposes that the exchange rate relates with the stock price, and vice versa, hence specific stock valuation shocks may be accountable for some cyclical exchange rate episodes in Nigeria.

The two *causality tests* – the symmetric and the (dynamic) asymmetric test – are evaluated. For the symmetric causality approach, I apply the Toda-Yamamoto test (see Toda & Yamamoto, 1995). The test, from the Wiener-Granger process, is implemented within the vector autoregressive (VAR)/vector error correction model (VECM) framework. The $VAR(p)$-process, from which short- and long run causality is directly inferred, holds K endogenous variables ($y_t = (y_{1t}, \dots, y_{kt}, \dots, y_{Kt})$), and is defined:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \quad (3)$$

Where A_i ($i = 1, \dots , p$) represents ($K \times K$) coefficient matrices, u_t is a K-dimensional process with $E(u_t) = 0$ and covariance matrix $E(u_t u_t^T) = \Sigma_u$ (white noise).

For the study's specific $EXRT_t - ASPI_t$ relation, the VAR(p) is:

$$EXRT_t = \alpha_0 + \sum_1^h \alpha_{1i} EXRT_{t-1} + \sum_1^h \alpha_{2i} ASPI_{t-i} + e_{1,t} \quad (4)$$

$$ASPI_t = \beta_0 + \sum_1^h \beta_{1i} ASPI_{t-1} + \sum_1^h \beta_{2i} EXRT_{t-i} + e_{2,t} \quad (5)$$

With $h = k + q$, lag (k), maximum cointegration degree (q), and system's residuals ($e_{1,t}, e_{2,t}$). Implying the causality between $ASPI_t$, and $EXRT_t$, the causality test is based on estimates (α_{2i}, β_{2i}) of the VAR system (Sims, 1980). The short (long) run causality is implied from significance of the *t*-tests of regressors (error correction term). The causality is strong, if both tests are significant. The causality tests the null $\alpha_{2i} = 0$ (i = 1, 2, …, p), supposing $ASPI_t$ does Granger cause $EXRT_t$, and β_{2i} supposing testing causality that $EXRT_t$ does Granger cause $ASPI_t$. The null of no granger causality is rejected null if the p-value of chi square is less than the 0.05, supposing the variable does not have any causal relationship at the critical level. The Wald test applies on the coefficients from the cointegration degree (dmax) of the variable that has maximum cointegration.

Table 1. Pre-test Information for $EXRT_t - ASPI_t$ Relation

x_t	$\mu(x_t)$	$\sigma(x_t)$	$\sigma(\mu)$	$\tilde{\mu}_3$	$\tilde{\mu}_4$	$\widetilde{JB}_{stat}$	$\sigma_{x_1x_2}$
Basic Statistics (deterministic Property)							
$EXRT_t$	2.255	0.185	0.011	0.728	2.097	33.30	-
$ASPI_t$	4.413	0.207	0.013	-0.922	3.775	45.40	0.547*
Stationarity test (stochastic property)							
Variable	**Deterministic**	**Terms**	**Lag**	**Test Stat.**		**CV**	

	Trend	Constant		τ_{adf}; τ_{pp}	1%	5%	10%
$EXRT_t$	Yes	Yes	3	-1.417	-3.993	-3.427	-3.137
$ASPI_t$	Yes	Yes	2	-2.714	-3.993	-3.427	-3.137
$\boldsymbol{EXRT_t}$	**Yes**	**Yes**	**0**	**-1.454**	**-3.993**	**-3.427**	**-3.137**
$\boldsymbol{ASPI_t}$	**Yes**	**Yes**	**0**	**-2.876**	**-3.993**	**-3.427**	**-3.137**
$\Delta EXRT_t$	None	None	1	-10.489*	-2.574	-1.942	-1.616
$\Delta ASPI_t$	None	None	1	-13.802*	-2.574	-1.942	-1.616
$\boldsymbol{\Delta EXRT_t}$	**None**	**None**	**0**	**-9.478***	**-2.574**	**-1.942**	**-1.616**
$\boldsymbol{\Delta ASPI_t}$	**None**	**None**	**0**	**-13.782***	**-2.574**	**-1.942**	**-1.616**

Note: *For the variable x_1(exchange rate) and x_2 (ASI), the basic statistics, $\mu(x_t)$, $\sigma(x_t)$, $\sigma(\mu)$, $\tilde{\mu}_3$, $\tilde{\mu}_4$, $\widetilde{JB}$, $\sigma_{x_1x_2}$, respectively, for minimum, mean, ,median, maximum, standard deviation of x_t, standard of the mean (μ), skewness coefficient, kurtosis coefficient, JB statistics and the Pearson correlation coefficients.*

** Statistical significance at 1% level (using the probability, $p|t| = 0$).*

The **bold** figures represent values for the PP tests

For the symmetric causality, I apply the Hatemi-J asymmetric test (Hatemi-J, 2012). Hatemi-J (2006) examine causality when the variables are integrated of degree one, two or three with drift and trend terms. Hatemi-J (2012) considered only I (1) variables without deterministic drift or trend component, whereas Hatemi-J (2012) – the consider method – establish asymmetric causality test with variables involving deterministic trend terms. The test assumes that positive and negative perturbations exert different causal impacts, hence, separates integrated series, (*I(d)*), into positive and negative cumulative terms. Since log- exchange rate and share price's are I(1) with drift (a) and trend (t), they are expressed as:

$$EXRT_t = a + bt + EXRT_{t-1} + \varepsilon_{1t}$$

$$ASPI_t = a + bt + ASPI_{t-1} + \varepsilon_{2t} \qquad (6)$$

The residual estimates are defined, $\varepsilon_{1t} = (EXRT_t - EXRT_{t-1}) - a - bt$, and $\varepsilon_{2t} = (ASPI_t - ASPI_{t-1}) - a - bt$. Equation (6) express as positive and negative partial sums is recursively shown with initial values ($EXRT_0, ASPI_0$) as:

$$EXRT_{1t}^{+} := EXRT_0 + \sum_{1=1}^{t} \varepsilon_{1i}^{+}$$

$$EXRT_{1t}^{-} := EXRT_0 + \sum_{1=1}^{t} \varepsilon_{1i}^{-}$$

$$ASPI_{2t}^{+} := ASPI_0 + \sum_{1=1}^{t} \varepsilon_{2i}^{+}$$

$$ASPI_{2t}^{-} := Bvol_0 + \sum_{1=1}^{t} \varepsilon_{2i}^{-} \quad (7)$$

Positive and negative shocks of any random variable ε_t ($\varepsilon_{1i}^{+}, \varepsilon_{1i}^{-},$) are identified as:

$$\varepsilon_{1t}^{+} := \max(\varepsilon_t, 0) := (\max(\varepsilon_{1t}, 0), \cdots, \max(\varepsilon_{nt}, 0))$$

$$\varepsilon_{1t}^{-} := \min(\varepsilon_t, 0) := (\min(\varepsilon_{1t}, 0), \cdots, \min(\varepsilon_{nt}, 0))$$

The accumulative positive ($\varepsilon_{1i}^{+}, \varepsilon_{2i}^{+}$) and negative ($\varepsilon_{1i}^{-}, \varepsilon_{2i}^{-}$) values follow:

$$\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0), \varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0), \varepsilon_{1i}^{-} = min(\varepsilon_{1j}, 0), \varepsilon_{2i}^{-} = min(\varepsilon_{2i}, 0).$$

Asymmetric causality uses the Sims (1980)'s system. The Granger causality between the RHS components of (7) is separately recognised and verified. In testing causality between two positive components (e.g., $EXRT_{1t}^{+}$; $ASPI_{2t}^{+}$), the VAR consisting of the variables is:

$$EXRT_t^{+} = A_0^{+} + A_1^{+} EXRT_{t-1}^{+} + \cdots + A_p^{+} EXRT_{t-p}^{+} + A_{p+1}^{+} EXRT_{t-p-1}^{+} + v_t^{+}$$

$$ASPI_t^{+} = B_0^{+} + B_1^{+} ASPI_{t-1}^{+} + \cdots + B_p^{+} ASPI_{t-p}^{+} + B_{p+1}^{+} ASPI_{t-p-1}^{+} + v_t^{+} \quad (8)$$

The model's persimmons parameterisation requires an optimal lag (p) using the Hatemi-J Criteria (HJC) below (see Hatemi-J, 2003).

$$HJC = \ln(|\Pi_p^{+}|) + p\left(\frac{n^2 lnT + 2n^2 \ln(lnT)}{2T}\right), p = 1, \ldots, p_{\max} \quad (9)$$

$|\Pi_p^{+}|$ is the determinant of the variance–covariance matrix of the error terms (Π_p^{+}) in the VAR. The Null that the jth element of $EXRT_t^{+}$ does not cause the kth element of $ASPI_t^{+}$ [H_0: $C\beta$ = 0] is tested using the Wald (1939) statistic (12), based on the VAR specification:

$$Y = DZ + \delta \quad (10)$$

Where: $Y := (y_1^{+}, \ldots, y_T^{+})$ $(n \times T)$ matrix,

$D := (v, A_1, \ldots, A_p)$ $(n \times (1 + np))$ matrix,

$$Z_t = \begin{bmatrix} 1 \\ y_t^{+} \\ y_{t-1}^{+} \\ \vdots \\ y_{t-p+1}^{+} \end{bmatrix} \quad ((1 + np) \times 1) \text{ matrix} \quad (11)$$

$D := (Z_0, \ldots, Z_{T-1})$ $((1 + np) \times T)$ matrix, and,

$Y := (u_1^{+}, \ldots, u_T^{+})$ $(n \times T)$ matrix.

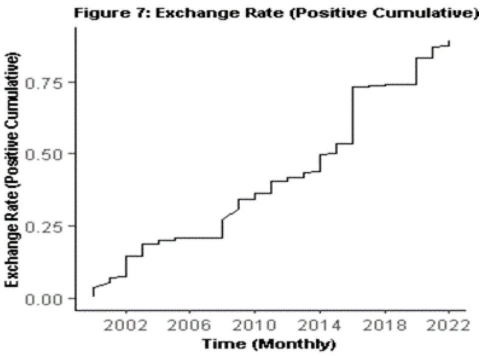
$$Wald = (C\beta)'[C((Z'Z)^{-1} \otimes s_U)C']^{-1}(C\beta) \quad (12)$$

$\otimes$ is Kronecker product and $\beta = vec(D)$, where vec is a column stacking operator. s_U indicates the variance covariance matrix calculated for the VAR as in $s_U = \hat{\delta}_U{}'\hat{\delta}_U/T - q$. $Y = DZ$, $Z_t\,((1+np)\,\times 1)$ matrix, $:= (y_1^+, \ldots, y_T^+)'$. The asymmetric causality test's critical values materializes from the bootstrapping algorithm with leverage conditions. The null does not hold at the defined α-significance level, if the generated Wald test is greater than the bootstrap algorithm' critical value (c_α^*) (Lutkepohl, 2005; Hatemi-J, 2003).

4. Analysis

According to standard procedure because the two variables are integrated, the optimal lag is confirmed and lag-length of 2 is chosen based on AIC for the cointegration's parametric parsimony of the exchange rate-stock price equilibrium, covering 2000:04-2022:09. I implement the cointegration, from the Trace and Max-Eigen tests, and the evidence at 5% supposes 2 co-integrating combinations, at which both Trace (32.451) and maximum-eigenvalue (18.043) statistics are slightly lower than the associated critical value of 12.318 and 2.634. Since equilibrium relation exists between exchange rate and stock price, same lag length is applied for the VECM's parameterisation in which the symmetric causality is inferred.

In the application of the asymmetric test, I transform the exchange rate and share price to the cumulative negative and positive deviations, inclusive of the drifts. The cumulative sums of positive and negative parts for the variables aids the tests for the asymmetric causality. Refer Figure 3 and 4 (5 and 6) show the plots for the log-scaled (first difference) exchange rate and share price, which reveal both as integrated with deterministic trend. Figure 7 and 8 (9 and 10) illustrate the exchange rate (share price index) into positive and negative cumulative terms. Table 2 reports both causality tests results.



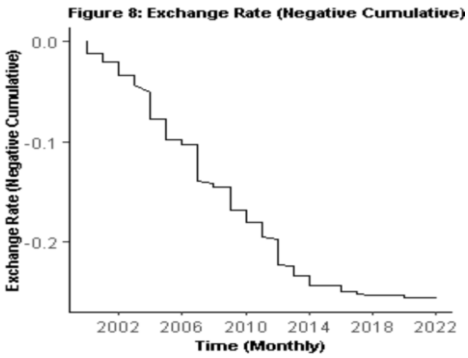


Figure 9: Share Price Index (Positive Cumulative)

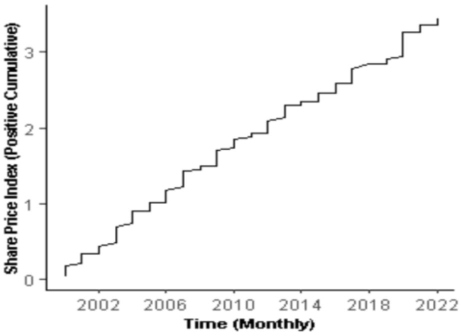
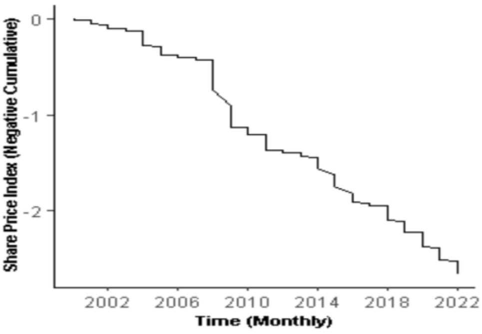


Figure 10: Share Price Index (Negative Cumulati



For the Toda-Yamamoto test, from the implemented VECM framework (untabulated), the null ($EXRT_t \nRightarrow ASPI_t$) does not hold. The Wald's Chi-square statistic of 5.852 was significant at 5% recognizing Granger causality from exchange rate to stock price. This is inconsistent with other authors (Hatemi-J & Irandoust, 2002; Suriani et al., 2015; Nusair & Olson, 2022). Hatemi-J and Irandoust (2002)'s findings for Swedish, who show that a rise in stock price is well connected with notable Krona appreciation. Suriani et al. (2015) find that the Pakistan KSE-100 index (stock price) and Rupee per Dollar (Rs/US$) are completely independent of each other, and no causality exist between them. Nusair and Olson (2022) examine G7 countries' data confirms that causality runs from stock prices to exchange rates in almost all the countries. The potential feedback is not established as the null ($ASPI_t \nRightarrow EXRT_t$) holds, for the causality from stock price to exchange rate, supposing no causal effect. There is evidence that, stock price may be affected more by factors that mostly influence the firms' profit, and when the profit falls, stock price would be lower and vice versa (Eldomiaty et al., 2020).

The symmetric procedure supposes that a unidirectional causality is evident for the system, albeit, from exchange rate to stock price. According to asymmetric causality, it is evident that a positive shock in the exchange rate can cause a positive shock in share price ($EXRT_t^+ \nRightarrow ASPI_t^+$). This implies that any depreciation or devaluation of the naira would motivate investors to increase their participations in the stock exchange market. The finding supports the flow-oriented model, where the Granger causality runs unidirectional from the exchange rate to stock price stock price, and the relation can be positive (Ajayi & Mougoue, 1996; Umoru & Asekome, 2013; Gudmundsson, 2014) or even negative (Mwanza, 2014; Mlambo et al., 2013).

Ajayi and Mougoue (1996) observe that depreciation has an adverse short-run or/and long-run effects on stock values. Gudmundsson (2014) explains that exchange rate affects stock price through its impact on real activities. A fall in the exchange rate would cause the competitiveness of domestic goods relative to foreign ones to rise, hence, lead to increase in aggregate demand and output of the domestic economy. With exports becoming cheaper, the real exchange rate will appreciate overtime causing a rise in real domestic activities. This will have an incremental effect on firms' expected future cash flow, and cause increase in the share prices of firms listed on stock markets. Umoru and Asekome (2013) explain that the positive impact could result from the appreciation of exchange rate leading to the lowering of input cost on the part of listed firms, leading to higher profitability and share prices.

For appreciation in the exchange rate, the result does not identify a Granger cause effect on the stock price ($EXRT_t^- \nRightarrow ASPI_t^+$). Evidently, a positive, i.e., $ASPI_t^+ \nRightarrow EXRT_t^-$ (negative, i.e., $ASPI_t^- \nRightarrow EXRT_t^+$) shock in the share price can cause an appreciation (depreciation) shock in the exchange rate according to established theory. A rise in stock price gives investors' confidence that the economy is growing, leading to increased motivations from foreign investors and demand for naira would increase causing it to appreciate. Conversely, if the Nigerian stocks underperforms, investors' confidence falters and even current investors withdraw their own currencies, causing the naira to depreciate. This means that any investment activities that translate into increase (decrease) shares price for the markets, can results in a appreciation (depreciation) of the naira per dollar. The asymmetric causality test further reveals that a negative shock in naira exchange rate does not Granger cause negative shock in the share price ($EXRT_t^- \nRightarrow ASPI_t^-$), and vice versa as well as a positive shock in naira exchange rate does not Granger cause negative shock in the share price ($EXRT_t^+ \nRightarrow ASPI_t^-$).

The connections between them would make investors to use information available in one market for speculation and hedging, in the other market. Understanding the links between both assets prices is important because the findings support predictions for short- and long run future price movements. Because the two markets play key role in international business, understanding the relationship between them may help investors to minimum risk and optimally invest (Suriani et al., 2015).

Table 2. Exchange rate and stock price causality test

Symmetric (Toda-Yamamoto) causality for exchange rate–stock price:

Test direction	**Lag**	**χ^2-stat.**	**p-value**
$EXRT_t \nRightarrow ASPI_t$	2	5.852**	0.0436
$ASPI_t \nRightarrow EXRT_t$	2	1.593	0.4507

Asymmetric (Hatemi-J) causality test for exchange rate–stock price:

			Bootstrap critical values		
Test direction	**Test-stat.**	**Lag**	**1%**	**5%**	**10%**
$EXRT_t^+ \nRightarrow ASPI_t^+$	5.118*	2	6.254	5.094	4.521
$ASPI_t^+ \nRightarrow EXRT_t^+$	1.029	1	5.492	2.766	1.904
$EXRT_t^- \nRightarrow ASPI_t^-$	1.512	2	7.079	2.543	1.879
$ASPI_t^- \nRightarrow EXRT_t^-$	1.246	1	5.608	4.838	1.925
$EXRT_t^+ \nRightarrow ASPI_t^-$	0.926	1	9.056	2.484	0.066
$ASPI_t^+ \nRightarrow EXRT_t^-$	1.312**	2	4.378	1.694	0.984

$EXRT_t^- \nRightarrow ASPI_t^+$	1.083	2	5.444	3.776	1.768
$ASPI_t^- \nRightarrow EXRT_t^+$	6.453*	2	4.295	4.110	1.573

Note: *$\nRightarrow$ indicates the causality null (e.g., $EXRT_t \nRightarrow ASPI_t$; implies that exchange rate does not cause stock price). Test-stat.: is the Wald statistic. **p<0.05; ***p<0.01. The critical values are generated from the bootstrapping algorithm with leverage conditions.*

5. Conclusions

A significant relationship between stocks and foreign exchange supposes that the shocks in one market could transmit to the other market. Hence, a number of studies have been made to examine the causality between their prices. These researches aim to verify the flow-oriented model, from Dornbusch and Fisher (1980), that supposes that it is the exchange rates that determines the stock prices or the flow-oriented models from that Frankel (1983) that support that it is stock prices that drive the exchange rates. Available evidence for Nigeria has involve different authors completing over-parameterized, short run or/and long run, models to examine the relationship between the two variables, and sometimes involving 'redundant' financial and macroeconomic variables. The result has always been mixed, and do not appear to consider asymmetric implications of the exchange rate-stock price situation in the precarious markets. Because preliminary investigation, based on the unit root confirmation, identifies that the two considered series are trended and integrated, I test the relationships between both variables from symmetric approach, from Toda-Yamamoto (1995) and the asymmetric approach for handling causality from Hatemi-J (2012).

The results from the symmetric method recognise causality evidence from Naira exchange rate to stock price with no potential Granger-causal feedback. Since allowing for asymmetry has significant repercussions for underlying causal inference of the variables, I extend the aim to verify the likelihood of lopsided causality by transforming the naira exchange rate and stock prices series into positive and negative cumulative fragments, and complete the asymmetric causality tests using the Wald statistic. The results identify that allowing for asymmetry, and in particular, positive shocks in the exchange rate can cause a positive shock in share price, and not vice versa. Also, negative shocks in the exchange rate would not cause a negative shock in share price. This implies that any depreciation or devaluation of the naira would motivate investors to increase their participations in the stock exchange market. These finding has vital policy implications to different stakeholders, including Government, regulators, currency- and stock markets traders and others in the Nigerian context. Overall, the evidence aids international portfolio investors in making informed portfolio diversification decisions and risk hedging strategies, as well as offers useful insights for policy makers.

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