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WHERE DO REAL OUTPUT SHOCKS TO NIGERIA MAINLY EMANATE FROM? EMPIRICAL ANALYSIS OF NIGERIA-CHINA-INDIA-USA ECONOMIC INTERACTIONS

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Abstract: This study investigated Nigeria's economic interactions with China, India, and the USA with a view to identifying the main source of real output shock to Nigeria in the period 1981Q1-2019Q4. The analysis followed the network approach of Diebold and Yilmaz (2014), which uses the size and direction of normalized generalized forecast error variance decompositions (NGFEVD) of a vector error correction model to track shock propagation among economic entities. The results indicate that China and India are net transmitters of real output shocks to Nigeria. The results also indicate that Nigeria is a net real output shock receiver. The study concludes that Nigerian policymakers should evolve policies that can insulate the economy against real output shock heatwaves from around the world, especially China and India. Such policies should mainly target the diversification of the economy such that crude oil will no longer be the only major source of revenue.

Keywords: Output Shock Transmission; Network Approach; VAR Model; Nigeria.

JEL Classification: F02; C32; P16; N17.

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1. Introduction

Global business cycles and financial uncertainties are effortlessly transmitted to low-income and developing countries such as Nigeria through several channels like trade and capital flows. Samake and Yang (2014) identified trade as the most notable transmission channel mechanism. Biljanovska and Meyer-Cirkel (2016) suggest that notwithstanding the low trade activities involving most developing and low-income nations, they are nonetheless very much exposed to world business uncertainties. The authors maintained that poor and developing economies like Nigeria are quite vulnerable to shock transmissions from the United States of America (USA or US) and other developed and emerging market economies like China, India, and Brazil. They however opined that in specifics, oil and primary commodity-exporting nations have a high level of connectedness or linkage with emerging market economies, which leaves them with a high degree of vulnerability against shocks which could be either output or financial. The focus of this study is on output shock transmission from China, India, and the USA to Nigeria. Specifically, this study is aimed at identifying the main source(s) of real output shocks to Nigeria.

Spillovers wield enormous influence and dictate the conditions of real gross domestic product (GDP) specifically in developing and emerging economies (Anaya, Hachula & Offermanns, 2017). Bayoumi and Swiston (2009) found that spillovers from the USA constitute the largest spillover indices received by most developing economies. This implies that the USA originates and transmits real and financial shocks to developing nations. Greenwood-Nimmo, Nguyen, and Shin (2015) demonstrated that the major drivers of the global economy are the USA, Eurozone, and crude oil market, with China playing a non-negligible role. Also, Greenwood-Nimmo, et al (2021) posit that the US exerts a major influence on the global economy whereas the activities of countries like China, Brazil and Eurozone are as well globally important. Shock spillovers among G-7 economies rose exceptionally between the periods 1958 and 2013 with the USA being the major transmitter (Antonakakis & Badinger, 2016). Quantitatively, 0.3% - to 0.4% reduction in the USA's output growth yields an instant reduction of Nigeria's GDP by 0.1% and averages to almost 0.6% over time. On average, an increase in the USA's interest rate leaves the emerging market economies (EMEs) with rising short-run and long-run interest rates. Specifically, a 1% rise in the USA's financial uncertainty increases short-term and long-term interest rates by 0.0035% and 0.012% respectively. The rise also decreases stock prices by 0.125%; capital to GDP outflow by 0.0175%; and local currency depreciation by 0.045% (Bhattarai, Chatterjee, & Park 2017). Also, the authors observed that monetary policy shock in

the USA destabilizes real activities of the emerging market economies (EMEs) by a 0.035% fall in GDP.

On the other hand, China in recent times has been categorized as an economic heavyweight considering its recent economic fortunes and influence on industrial and developing economies, Nigeria inclusive. Many analysts have attributed these fortunes to good policy, good practice and good luck, which can be referred to as '3Gs'. Indeed, China is an economic leader relative to other EMEs. A negative shock to China's economy causes an instantaneous decline of about 0.08% in Nigeria's GDP growth and the fall progresses further to about 0.26% on average over time (Oyelami & Olomola, 2016). Cashin, Mohaddes and Raissi (2017) also show that output slowdown in China has a high impact on the economies of commodity-exporting countries. Consistent with Cashin et al. (2017), Inoue, Kaya, and Ohshige (2015) noted that negative shock to China's output growth is transmitted effortlessly beyond its shores as it largely affects commodity exporters like Japan, Indonesia, Thailand, Singapore and Malaysia, and pulls down the prices of crude oil, metal and agricultural products. This also implies that since Nigeria is classified as a primary commodity exporter with crude oil as a dominant export product, shocks to China's economy will easily be transmitted to the Nigerian economy. This can be attributed to the high volume of trade between both countries.

Descroches (2004) shows that there are different patterns of shock transmission or spillover among emerging economies like India and China. Recently, India has been classified as a strong force or leader among the emerging market economies, even though Lakdawala and Singh (2019) found that external shocks took a huge toll on her stock market, exchange rates and foreign exchange reserves. Nonetheless, low-income countries (LICs) like Nigeria have become increasingly interwoven with emerging markets economies such as India through trade links, growing cross-border financial asset holdings and capital flows as well as higher remittance flows (Dabla-Norris, Espinoza & Jahan, 2015). Shocks coming from emerging market leaders such as India, China and Brazil have been identified to influence the economic activities of the low- and middle-income nations, including Nigeria (Espinoza, Jahan, and Dabla-Norris 2012). This implies that output shocks from emerging market leaders like India can easily be transmitted to the Nigerian economy, thereby influencing the domestic conditions of the Nigerian economy. Samake and Yang (2014) observed that there is a direct shock spillover transmission from Brazil, Russia, India, China, and South Africa (known as BRICS) economies to low-income economies and that Nigeria is a recipient of such shock. They identified trade as the most important transmitting channel.

BRICS is an acronym of the economic bloc consisting of the aforementioned emerging market economies.

In general, trade has been identified as the major driver of spillover and the main channel through which output shock could be seamlessly propagated to any economy across the globe. United Nations Commodity Trade Statistics (hereafter, UN Comtrade, 2019) indicates that India and the USA are among the top export markets for Nigeria, while China, India and the USA are Nigeria's top import sources. This gives some insights into how vulnerable Nigeria could be to output shocks originating from any of these economies. Figure 1 shows the percentage contribution of trade to GDP for all the economies in this study. It shows that all the economies display a similar pattern, that is, they relatively track themselves. This underscores how connected the economies could be through time. India and China have higher percentages of trade to GDP contribution than the USA and Nigeria. This simply describes how these two emerging market economies have grown from relatively inconsequential economies in the 1980s to significantly important economies in recent times.

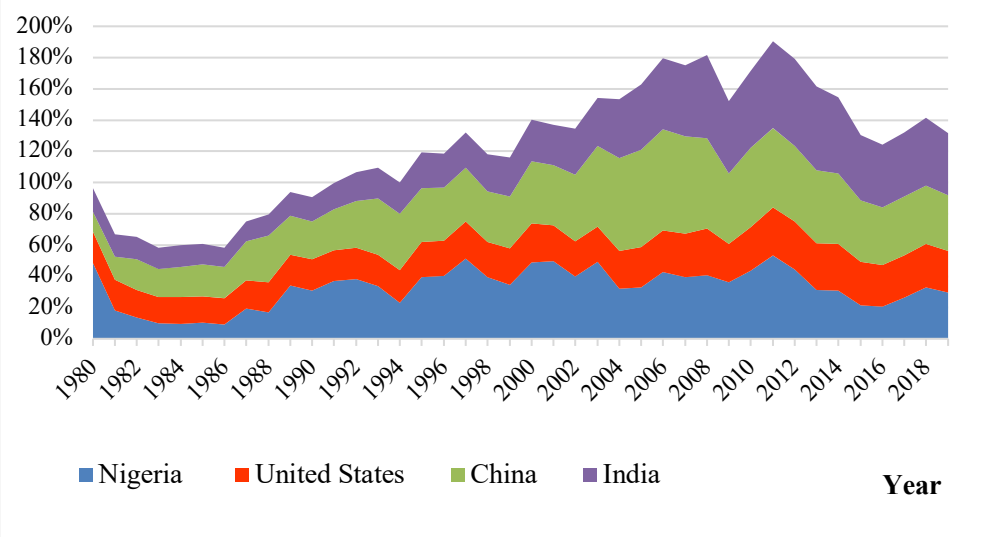

Figure 1 Total Trade as a Percentage of GDP for China, United States, Nigeria and India from 1980-2019

Source: Authors' computation using WDI dataset, 2019.

Most studies (Greenwood-Nimmo, et al. 2021; Greenwood-Nimmo, et al. 2015; Inoue et al. (2015); and Ogbubor, et al. 2018) in the extant literature have

investigated the direction of spillovers from systematically important economies like Japan, Canada, United Kingdom, Euro area, and the USA to emerging economies notably China, India and Brazil and vice versa. Unfortunately, studies involving output connectedness and shock transmission of low-income economies like Nigeria, especially with their major trade partners are scanty in the literature. This is particularly so for output shock propagation. It is the goal of this study to address this gap in the literature. The remainder of this paper is organized thus: literature overview in section 2, methodology in section 3, empirical results and discussion in section 4 while the conclusion is found in section 5.

2. Literature Overview

One cannot discuss economic linkages among countries induced by trade without discussing the theory of the business cycle. Economic linkage among countries exposes countries to output shocks and fluctuations originating from major trade partners. The theory of the business cycle tries to explain the boom and burst feature of real business activities. No economy can maintain a steady boom forever; every economic boom will usually be followed by a burst. Business cycle theory is built on two major hypotheses: financial and trade linkage hypotheses. Forbes and Claessens (2004) note that the financial linkage hypothesis suggests that financial ties influence the global business cycle and international financial contagion such that crisis in an economy could reduce its ability to receive (supply) capital from (to) other economies through remittances, foreign direct investment (FDI), trade credit and other channels of capital flows. Imbs (2006) argues that a rise in financial connectedness among countries kindle rise in the world business cycle and fluctuation in both output and consumption. Similarly, Eichengreen, Hale and Mody (2001) posit that transcontinental contagion spreads speedily to countries with stronger bilateral trade relations and familiar macroeconomic environments than to others with no strong trade ties. On the other hand, Forbes (2012) suggests that an economy is very vulnerable to shock if such an economy's trade is open in the face of weak macroeconomic policies.

Some notable empirical facts in relation to the present study are summarized as follows. Bettendorf (2017) used a global vector autoregression (VAR) method to investigate the world imbalances with a range of data set between 1981Q1 and 2011Q2 encompassing 33 nations. This study shows that the volatilities of the USA's real stock and oil prices as well as its real output growth have a crucial influence on the fluctuations of trade balances. The study however states that upward shock to the real equity prices of the USA has a negative effect on its trade stability though not statistically significant. The study concludes that prices of US equity remain the major diver of trade stabilities. Diebold and Yilmaz (2009)

investigate how connected the world equity markets are from January 1992 to November 2007. The results show differing behavioral changes for equity returns and shocks to equity returns volatilities. While equity returns spillovers show a clear mild trend devoid of bursts, equity return volatilities demonstrate no drift/trend but a clear burst. A recent study by Greenwood-Nimmo, et al (2021) measure the connectedness of the global economy employing forecast error variance decomposition (FEVD) of an underlying VAR model that covers 25 economies. The study reveals that the US wields major influence on the global economy whereas economies such as Brazil, China and Eurozone remain equally globally significant. Their recursive estimates showed that during the global financial crisis, shocks to world equity markets are spread swiftly and forcefully to real trade flows and real GDP. Exploring the cyclical structures and dynamic spillovers among monetary policy cycle, financial cycle and business cycle in China between 1998 and 2018, Li, Yan and Wei (2021) found that five cycles display strong connectedness with respect to response to extreme events such that spillovers among them are bidirectional and time-dependent. The study represented the financial cycle by credit, housing and stock market cycles. Also, the results show that the stock market is the major transmitter of risk after the global financial crisis while credit and monetary policy cycles emerged as main risk receivers. In a similar study, Benlagha and Hemrit (2021) investigated the causes of linkage between sovereign bond yields in G-7 economies employing Diebold and Yilmalz's (2012) network approach. The study employed monthly data between 2015 and 2019 and found that being a net transmitter or receiver of spillovers remains most likely independent and that the influences depend on the type of the sovereign bond yields.

He and Chen (2014) employed frequency domain and VAR techniques with data spanning from 1979Q1 to 2010Q4 to offer possible explanations to the stability of China's economy in recent times. The results show that good business practice, good policy and good luck hypotheses are the contributors to the recent stability of China's macroeconomic conditions. Inoue et al (2015) study the shock spillovers originating from the economy of China to Asia-Pacific countries involving 33 countries from 1979Q1 to 2014Q3. The findings are consistent with the results of Cashin et al (2017). Dizioli, Hunt, and Maliszewski (2016) applied the global vector autoregression (GVAR) method to analyze the effect of spillovers on five Association of Southeast Asian Nations (ASEAN). The findings reveal that the economies of the five ASEAN countries have declined by 0.3% as a result of a 1% decline in China's output growth. Duval, Cheng, Oh, Saraf and Seneviratne (2014) also find consistent results implying that spillover growth is more common and greater with countries that rely mainly on Chinese final demand. They find that a

1% decrease in the GDP growth of China on average translates into a 0.3% reduction of output growth of Asian countries and 0.15% for non-Asian economies. A study by González-Urteaga, Nieto and Rubio (2021) focused on the spillover dynamics between risk-neutral equity and treasury volatilities. The study essentially investigated the total and directional connectedness of risk-neutral volatilities from the equities and treasury markets in terms of spillover effects as well as the economic and monetary drivers of connection dynamics. The results observed strong net spillovers from the treasury to equities risk-neutral volatility most of the time, but especially during terrible economic periods. Treasury risk-neutral volatility is found to be a net transmitter of volatility to risk-neutral equity volatility. These findings are consistent on a daily and monthly basis. Over the course of more than two centuries, Umar, Riaz and Zaremba (2021) explored the interconnectedness of nine different commodity classes. Monthly observations from 1780 to 2020 are included in the data sample. Precious metals, soft foods, grains, and base metals are all shown to be net spillover transmitters in the static analysis whereas their time-dynamic analyses show that economic crises, political uncertainty, and commodity-driven supply shock all promote connectivity. Ibironke (2018) examined the channels of the spread of impulses with the use of the GVAR tool. The results contradicted the general belief that global volatility emanates mainly from only macroeconomic indices, rather they indicate that agent behaviors in terms of investment switching between markets or outright sale and reallocation of assets cause capital outflow, and thus economic crisis. Ghosh, Chourasiya, Bansal and Chandra (2021) examined the connectedness of markets with mixed agents and information cascading employing the dataset of the World input-output databank covering 28 economies of the European Union plus 15 additional economies. The study cuts across 56 industries between 2000 and 2014. The findings reveal that the interconnection of some markets in a global network is significantly linked to not only their size but also the direction of trades or cross-holdings and the industries that dominate their input-output data. The authors considerably project the cascades of failures in the network using growth model estimation.

Pham and Sala (2021) examine the degree and consequences of total and directional volatility spillovers across variables and nations, focusing on the G-7 economies plus Spain and using monthly high-frequency data in a macro setting. The authors confirm that the total interconnectivity of prices (58.28 percent) is higher than that of unemployment (41.81 percent). They also found country-specific asymmetries that lead to stronger short-run Phillips' curve trade-offs during recessions and lower trade-offs during booms. The authors further discover that volatility spillovers are amplified in times of common economic instability,

such as the Global Financial Crisis, this evidence is based on the examined time-varying connectivity coming from country-specific shocks. The impact of US economic policy uncertainty (EPU) on the interconnectivity of oil and the most widely traded currency pairings is examined by Fasanya, Adekoya and Adetokunbo (2021). First, the study looks at the correlation between oil and exchange rates, and discovers a strong link between crude oil and currency markets, with oil being net shock receivers. Second, the time-based dependence in series (BDS) test reveals that when studying the impact of EPU in influencing the interactions between oil and exchange rate markets, nonlinearity is critical. Third, the nonparametric quantiles-based causality test reveals that economic policy uncertainty around the lower and median quantiles drives the spillover for each asset. Finally, the findings underscore the importance of US economic policy in affecting the global financial cycle, which in turn influences capital flows and asset price movements across financial markets. The study by Bailey, Gupta, Hillenbrand, Kuchler, Richmond and Stroebel (2021) created a novel and publicly available measure of pairwise social connectivity between 170 nations and 332 European regions using de-identified Facebook data and found that when two countries are more socially connected, they trade more, especially for items with high information frictions. The findings further reveal that the regions where the product is produced in the exporting country and the regions where it is utilized in the importing country are the social ties that forecast trade in specific products. Using both dynamic spillover and nonparametric causality-in-quantiles techniques, Fasanya, Oliyide, Adekoya and Agbatogun (2021) investigate the influence of US EPU on the connection between bitcoin and precious metals. The results from the time-varying parameter vector autoregressions spillover test show considerable interconnectedness between the Bitcoin and precious metals markets. Secondly, the BDS test reveals that nonlinearity is a critical feature to consider when assessing the causal effect of economic policy uncertainty on Bitcoin and precious metals market interactions. Finally, the non-parametric causality-in-quantile test reveals that the market-economic policy uncertainty connection is strongest around the median and higher quantiles.

L. H. Nguyen, L. X. Nguyen and Tan, (2021) analyze the entire tail risk connectivity network of the entire US industry system using the Least Absolute Shrinkage and Selection Operator (LASSO) quantile regression technique. The study is comprised of 59 industries over a 12-year period between 2005 and 2016. The empirical relationship between input-output linkages and tail risk spillovers among US sectors is also investigated. The findings identify the tail-risk drivers, receivers, and distributors across industries, confirming that the real trade flow between businesses is a primary driver of their tail risk connection.

3. Methodology

Based on the theoretical literature thus reviewed, it is seen that the theory of trade linkage hypothesis best underpins this empirical analysis. This is simply due to its capacity to explain the trade interaction involving nations. However, following Diebold and Yilmaz (2014, 2015a), Ogbuabor et al (2016, 2018), and Park and Shin (2014), we adopted the network approach procedure, which uses the generalized forecast error variance decompositions (GFEVDs) of VAR to track shock propagation among entities. GFEVD is credited to Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998). According to Ogbuabor et al (2016), GFEVD is superior and preferred to Cholesky factorization and conditional correlation in that it is directional, non-pairwise and order-invariant. Hence, it suits studies of this kind. Identifying the most dominant economy in terms of capacity to transmit output shock requires that a connectedness matrix is built in line with Diebold and Yilmaz (2015a) and Ogbuabor et al (2016). This requires the construction of the influence index. To achieve this, we begin with the *p*-th order vector autoregression (VAR) model for the *N* x 1 vector of endogenous variables Y_t. The VAR(*p*) model is however represented thus;

$$Y_t = \varphi_y + \sum_{i=1}^{p} \beta_i \, Y_{t-p} + \nu_t \qquad (1)$$

where: Y_t is a vector of $K-$ endogenous variables; φ_y is *N* x 1 intercept vector; β_i, $i = 1, \dots p, are$ *N* x N matrix of coefficients; $\nu_t \sim iid\,(0, \sum_{\varepsilon})$ such that $\nu_t \sim (0, \sum_{\varepsilon})$ while $\sum_{\varepsilon}$ is a positive definite covariance matrix; and $t = 1,2, \dots T$ is the time dimension. The endogenous variables in this study consist of the log of gross domestic product (GDP) per capital (measured in constant 2010 United States dollars) for all the economies under study, starting from 1981Q1 to 2019Q4. Following the estimation of equation (1), the GFEVDs of Pesaran and Shin (1998) are then computed as:

$$GFEVD(\gamma_{it}, \varepsilon_{ji}, H) = d_{ij}(H) = \frac{\sigma_{\nu,ii}^{-1} \sum_{h=0}^{H-1} (\mu'_i \theta_h \sum_{\varepsilon} \mu_j)^2}{\sum_{h=0}^{H-1} (\mu'_i \theta_h \sum_{\varepsilon} \theta'_h \mu_i)} \qquad (2)$$

where: $i, j = 1,2 \dots N$; $\sum_{\varepsilon}$ is the calculated covariance matrix of the residual vector, ν; $\sigma_{\nu,ii}$ is the evaluated standard deviation of the residual for $i-th$ equation; θ_h is the multiplicative coefficient matrix of *h*-lagged shock vector of the non-orthogonal infinite moving average of the VAR representation; $\mu_i(\mu_j)$ is *N* x 1 selection vector whose $i-th\,(j-th)$ element equal to one with zero elsewhere; and *H=1,2,3,…*16 designates the forecast horizons. However, Diebold and Yilmaz (2014) notes that shocks are hardly orthogonal in the GFEVD domain and as such forecast error variance shares are not always unity. This means that aggregation of the row variance decomposition matrix, $d_{ij}(H)$, is not essentially equal to unity. This makes GFEVDs interpretation very cumbersome. In order to reinstate the

percentage interpretation, we again employ Diebold and Yilmaz (2014) strategy to normalize the GFEVD as:

$$\tilde{d_{ij}}(H) = \frac{d_{ij}(H)}{\sum_{j=1}^{K} d_{ij}(H)} \qquad (3)$$

where: $\sum_{j=1}^{K} \widetilde{d_{ij}}(H) = 1$ and $\sum_{j=1}^{K} \widetilde{d_{ij}}(H) = K$ by definition.

This normalization, therefore, allows the total sum of the generalized forecast error variance contributions of each variable in the system to equal 100. This is done by dividing the forecast errors due to each economy by the row sum of the forecast errors of every other economy in the system and multiplying the same by 100. This approach restores the percentage interpretation.

From equation (3), we forge ahead to build our connectedness matrix for our economies of interest. Accordingly, we define d_{ij} as the $H-$step ahead normalized GFEVDs. Cross-tabulating d_{ij}, the connectedness matrix is built, analogous to the connectedness matrix of Greenwood-Nimmo et al. (2015). The principal diagonal elements account for their own variance contributions symbolized as $d_{jj} = H_j$ whereas the off-diagonal elements account for variance contributions resulting from shocks to other variables denoted as d_{ji} such that $i \neq j$ in the system and it is also regarded as pairwise directional connectedness.

F_j measures the aggregate cross-variable forecast error variance (FEV) shares resulting from all other variables to y_{jt} where $i = 1,2, \dots, N$ and $i \neq j$. In simple terms, this accounts for the total directional connectedness index from every other variable in the system to y_{jt} known as *from-effect*. This is denoted as:

$$from - effect = F_j = \sum_{j=1, i \neq j}^{N} d_{ji} \qquad (4)$$

Analogously, the cumulative contributions of y_{jt} to every other variable in the system is defined as:

$$to - effect = T_j = \sum_{j=1, i \neq j}^{N} d_{ij} \qquad (5)$$

T_j reports the aggregate directional connectedness index from y_{jt} to other variables in the system. It displays the percentage of output shocks given by each economy to other economies in the system. This is also referred to as a measure of output influence that each of the economies wields on every other economy in the system. Subsequently, net-effect also known as the net directional connectedness index of y_{jt} can be defined as $N_j = T_j - F_j$. This net effect is also known as the total trade balance of each of the economies (Ogbuabor et al. 2018), where N_j = the net spillover effect for country j while other items remain as defined already. The above tools are simply used to construct the influence index to account for the most dominant economy in the system. The procedure is simple and is as follows:

$$Influence\ index = \boldsymbol{I_j^H} = \frac{N_j}{T_j + F_j}, \qquad \forall_j = 1,2,3, \dots N \quad (6)$$

where: $\boldsymbol{I_j^H}$ = influence index for country *j*; *H* = horizons, 1,2, 3,…16; and other items remain as defined. $-1 \leq \boldsymbol{I_j^H} \leq 1$. *j-th* country is a net receiver of output shock if $-1 \leq \boldsymbol{I_j^H} < 0$; a net shock transmitter if $0 < \boldsymbol{I_j^H} \leq 1$; and neither a net receiver nor transmitter of real output shock if $\boldsymbol{I_j^H} = 0$. This paper is also extended to ascertain the most dependent economy in the system. To achieve this, the *dependency index* is constructed as:

$$Dependence\ Index = \boldsymbol{D_j^H} = \frac{F_j}{H_j + F_j}, \qquad \forall_j = 1,2,3, \dots N \qquad (7)$$

where: *D*-index ranges between 0 and 1 ($0 \leq \boldsymbol{D_j^H} \leq 1$). If $\boldsymbol{D_j^H} \longrightarrow 1$, then the *j-th* economy is responsive to external output shocks arising from other economies in the system, and therefore considered open (or dependent); but if $\boldsymbol{D_j^H} \longrightarrow 0$, then *j-th* economy is less responsive to other countries' output shocks in the system and as such considered less open (or less dependent).

4. Empirical Results and Discussion

The descriptive statistics of the variables are captured by Table 1. The mean of the real output growths of the USA, CHN (China), IND (India) and NIG (Nigeria) are 10.64, 7.51, 6.78 and 7.45, respectively. The deviations around the mean of the variables (real output growths) are captured by their individual standard deviations (Std. Dev.). It is seen that all the variables exhibit some variations. It is also seen that there is large dispersion around the means of all the variables given the huge gap between each of the variable's standard deviation and their respective means (expected value). These can easily be checked by taking their respective differences.

Table 1 Descriptive Statistics of the Variables

	USA	CHN	IND	NIG
Mean	10.64	7.51	6.78	7.45
Median	10.71	7.48	6.72	7.35
Maximum	10.93	9.04	7.69	7.86
Minimum	10.25	5.87	6.07	7.19
Std. Dev.	0.19	0.96	0.49	0.24
Skewness	-0.43	-0.02	0.30	0.45
Kurtosis	1.97	1.75	1.86	1.56
Jarque-Bera	11.61	10.24	10.85	18.58
Probability	0.00	0.01	0.00	0.00
Sum	1660.14	1171.16	1057.28	1162.54
Sum Sq. Dev.	5.87	141.73	36.66	8.87
Observations	156	156	156	156

Notes: *USA=United States of America; CHN=China; IND=India and NIG=Nigeria.* Source: Self-research.

The economic implication of this implies that any shock to any of the series persists, that is, there is no possibility of mean reversion. With this revelation, one can anticipate that the series/variables may be nonstationary. However, on the standard normal distribution of the variables as captured by the Jarque-Bera test, it is seen that all the variables are shown not to follow a normal distribution curve given their small Jarque-Bera probability values ($p < 0.01$).

Table 2 Phillips-Perron Unit Root Test Results

With Constant and Trend					
Variables	**PP level Statistics**	**PP Level P-value**	**PP 1ST Diff. Statistics**	**PP 1ST Diff. P-value**	**Integration Order**
USA	-1.5423	0.8108	-5.2759	0.0001	*I(1)*
CHN	-1.4882	0.8298	-3.9064	0.0140	*I(1)*
IND	-1.5545	0.8062	-5.5994	0.0000	*I(1)*
NIG	-3.6277	0.0307	-	-	*I(0)*

Notes: *Diff = difference.*

Source: Self research.

For the purpose of this study, Phillips-Perron (PP) unit root test is employed to determine the stationarity condition of the series. This helps to produce robust regression for inferential purposes. Since PP test uses less restrictive measures and a more generalization and extension of the Augmented Dickey Fuller (ADF) test, it is however ideal that we employ it in this study. Table 2 displays the Phillips-Perron unit root test results for all the variables. The features of the variables under study inform the choice of inclusion/non-inclusion of constant and trend or both. A visual look of the line graph (found as figure 3 in appendix section) of the real output variables shows that all the variables are trending with a clear intercept hence the unit root tests are conducted with the inclusion of both constant and trend. The result shows that the USA, China and India real output growths are nonstationary in levels but became stationary after the first difference. Their level respective p-values (0.8108, 0.8298 and 0.8062) as reported by the PP test shows clear support of the null hypothesis at a 5% significant level; hence, we cannot reject the null. However, after first differencing, the series (the USA, China and India) became stationary given the $p < 0.01$ for USA and India, and $p < 0.05$ for China. This implies that they are all integrated of order one, *I(1).* Nigeria's real output growth is however stationary in level, that is, it has no unit root. This is given by the $p < 0.05$ (0.0307), that is, the null hypothesis of a unit root is rejected in favor of the stationarity alternative. This type of variable is otherwise known as *I(0)* (i.e integrated of order zero). These findings however prompt the need for a cointegration test.

Table 3 Johansen Cointegration Test Result

No of CE(s)	Trace Statistic	Probability values	Max-Eigen statistic	Probability values
None*	109.3989	0.0000	75.96990	0.0000
1	33.42901	0.3153	17.25443	0.4366
2	16.17457	0.4786	12.68315	0.3543
3	3.491422	0.8137	3.491422	0.8137

* Indicates rejection of the null hypothesis at 5% level.
Source: Self research.

Table 3 presents the cointegration test result, which shows that both the Trace and Max-Eigen statistics are in unison as they both identify one cointegrating equation at a 5% level. Therefore, the null hypothesis of no cointegrating relation among the variables is rejected in favor of the alternative that there is a stable long-run relationship among the variables. This implies the existence of an equilibrium relationship among the variables, hence the estimation of the underlying model in its vector error correction (VEC) form in the ensuing analysis.

Table 4 Influence and Dependence Indices

Country	*I*-index	*D*-index
USA	-0.36	0.33
CHN	0.38	0.07
IND	0.27	0.13
NIG	-0.15	0.07

Notes: I-index=influence index; D-index=dependence index.
Source: Self research.

Table 4 shows the influence and dependence indexes for all the economies under study averaged across all horizons following equations (6) and (7), respectively. The influence index shows that the USA and Nigeria remained non-influential in the propagation and spread of real output shocks in the system with -0.36% and -0.15% influence indices, respectively. Surprisingly, this means that the USA is a net receiver of real output shocks and thus, cannot propagate real activity shocks to Nigeria. This finding contradicts earlier results from Antonakakis and Badinger (2016); Bayoumi and Swiston (2009); and Greenwood-Nimmo et al. (2015), which pointed to the USA as the main originator and transmitter of real economic shocks. This unexpected result, however, cannot be unconnected with the limited number of economies sampled as well as the trade pattern between the two economies (Nigeria and USA). The emergence of China and India as net real output shock transmitters in the system is not surprising since both economies have maintained steady positive growths since the early 1990s following their successful economic

reforms as well as China's 3G effect. These findings are interestingly in agreement with the previous studies of Cashin et al. (2017), Inoue et al. (2015), Espinoza et al. (2012) and Samake & Yang (2014). These growth-led reforms have put the two economies on the world economic map as strong emerging market economies. Therefore, with their respective influence indices, 0.38% and 0.27%, China and India are capable of propagating and spreading real output shocks to Nigeria.

A typical example of how influential China has become is the rate at which it propagated and spread the novel coronavirus disease popularly known as COVID-19 to almost every part of the world including the USA, India and Nigeria. In sum, the results indicate that the USA and Nigeria are vulnerable to real output shocks originating mainly from China, which is the topmost real output shock transmitter in the system. Similarly, the estimated dependence indexes for all the economies showed unexpected results. The dependence indices for all the economies are less than 50%, a threshold where an economy is considered very open. The USA can be relatively considered open to external conditions given its dependence index of 0.33% when compared to other economies in the system. However, all the economies are considered less open given their small dependence indices. This result could be attributed to the limited number of countries included in this study.

We extend the analysis by capturing the directional *from-effect* and *to-effect* connectedness of the various economies. This is calculated following equations (4) and (5) and pictorially presented as Figure 2. This figure is akin to *the from-effect* and *to-effect* connectedness index in Ogbuabor et al. (2016). The intuition behind this is to see at a glance the respective ability of each economy in the system to propagate output shocks across the various horizons. We can see that for the USA labeled "a", the amount of real output shocks that it receives from other economies in the system is way beyond what it gives. This however buttresses the declining role of the USA as revealed by the influence index. China transmits larger real output shocks in the system than it receives from other economies. This does not only portray China as the most dominant economy in the system but also as predominantly the net transmitter of real output shocks. This is represented by "b" under figure 2 above. The chart denoted as "c" above under figure 2 shows India's *from-others* and *to-others* connectedness index. Just like China's chart, India's *to-effect* curve is also larger than its *from-effect* curve, showing that the amount of output shocks India receives from every other economy in the system is below what it gives to others. This equally puts India as a net transmitter of real output shocks in the system. Finally, Nigeria's *from-effect* and *to-effect* connectedness index is shown by the chart labeled "d" under figure 2. One can verify from the chart that the index has no sustained pattern. Explicitly, from horizon 1 to horizon 11, the real output shock that Nigeria receives from other economies in the system

is beyond what it gives to others, but the situation changed after the intersection of the two curves at horizon 12 when the real output shocks that Nigeria receives from other economies became less than what it contributes to others. Regardless of the fortunes observed for Nigeria, the country nonetheless remained a net receiver of real output shocks as seen in its influence index. Indeed, these results are impressively consistent with the already reported influence indices.

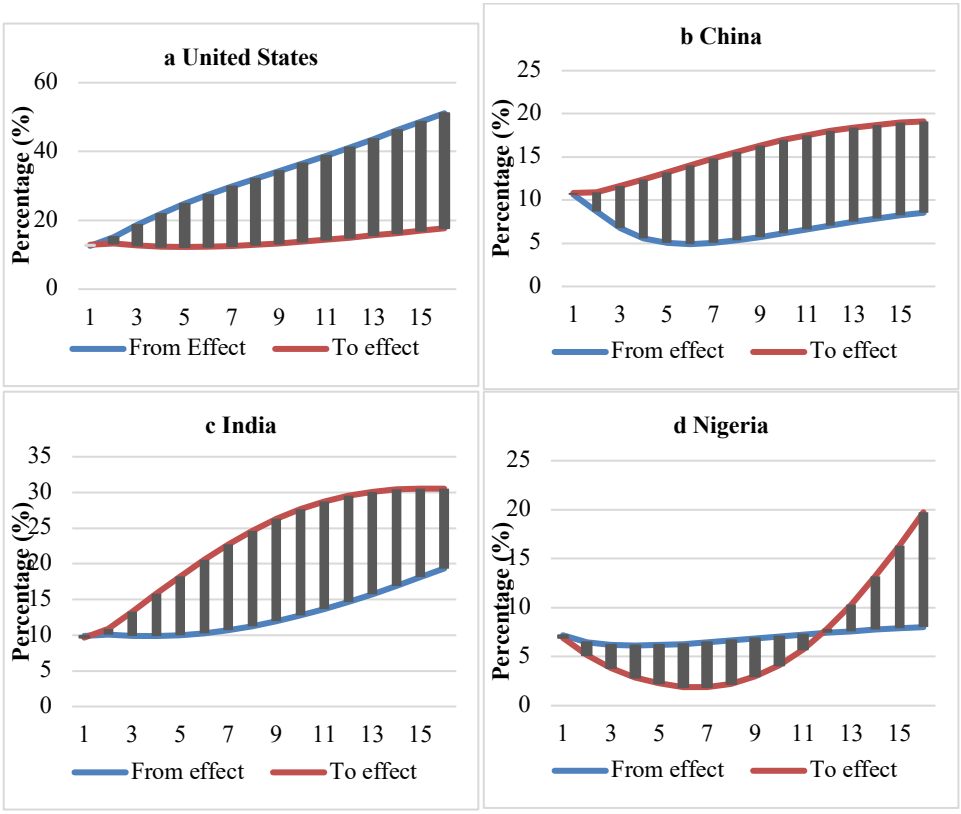

Figure 2 *From-effect* and *to-effect* Connectedness of the Economies
Source: Self research.

5. Conclusions

This study investigated the patterns of real output shock transmission from China, India and the USA to Nigeria with a view to establishing the economy or economies that has the potential of transmitting real activity shocks to Nigeria. The study adopted a network approach which uses the normalized GFEVDs of an

underlying vector autoregression model to track the size and direction of shocks. The data spans the period 1981Q1-2019Q4. The findings indicate that China is the most influential economy and therefore dominates the system with an influence index of 0.38%. This implies that China is a net real output shock transmitter, especially to the Nigerian economy. This finding is however consistent with the empirical facts of Greenwood-Nimmo et al, (2021) which showed that China is globally significant. Emerging also as a strong real output shock transmitter is India with an influence index of 0.27%. This placed India as the top influential economy in the system after China. India is nevertheless noted to possess the capacity to propagate real output shock in the system particularly to the Nigerian economy. Confirming the result found with respect to China and India are: Espinoza et al., (2012), Cashin et al. (2017), Inoue et al. (2015), and Samake and Yang (2014) whose empirical findings suggest that economic shocks due to emerging market leaders such as China and India are identified to influence the economic activities of low-and middle-income economies like Nigeria. The negative influence indexes of the USA and Nigeria indicate that neither of the two economies is capable of propagating real output shock in the system. This result is also infirmed by Greenwood-Nimmo et al., (2021); Bettendorf (2017) which observed that the USA wields major influence on the global economy hence the real shock transmitter. Other earlier studies that contradict our influence index findings with respect to the USA are: Antonakakis and Badinger (2016); Bayoumi and Swiston (2009) and Greenwood-Nimmo et al. (2015) which pointed to the USA as the main originator and transmitter of real economic shocks.

That Nigeria is a less influencer and net receiver of shock in the system is corroborated by Forbes (2012) and Ogbuabor et al. (2016). According to Forbes (2012), an economy whose trade is open with a weak macroeconomic framework is most likely vulnerable to shocks. Therefore, the result with respect to Nigeria could be due to Nigeria's degree of trade openness as well as the nature and strength of her macroeconomic policies. Also, Ogbuabor et al. (2016) confirmed that African economies (which Nigeria is part of) are highly less influential and this empirical fact is consistent with ours for the Nigeria case. The dependence index results indicate that all the economies are less open given their individual dependence indices which are below the 50% average. The dependence index with respect to Nigeria contradicts findings of Ogbuabor et al. (2016) whose findings suggest that African economies (whose continent Nigeria belongs to) are majorly dependent but less influential. This result has, however, been attributed to the limited number of economies in the sample.

With respect to our findings, we recommend that; a) Nigerian policymakers should be watchful in order to mitigate the effects of adverse headwinds coming from the

country's top trade partners, notably India and China. The economy of Nigeria needs immediate diversification from single revenue source (i.e., crude oil) to other sources of revenue such as agriculture, solid minerals, technology, human capital and information and communication technology (ICT). Such diversification policy will help in insulating the economy against any possible real output shocks from around the world; b) Since China and India emerged as real output shock transmitters placing them as influential economies with relative less vulnerability to real output shocks. In view of this, policymakers in these economies are advised to sustain their existing policy frameworks so as to remain influential globally; c) Policymakers in the USA should introduce policies that would strengthen the country's role in the system, especially in Nigeria. This can be done through trade policies and by renegotiating bilateral trade relations involving the country and these economies, especially Nigeria; d) Policymakers in the USA should also be very wary of real output shocks emanating from China and India. They should be vigilant with anti-spillover policies such as improving USA trade relations with other countries of the world.

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Author Contributions
AO and IPN conceived the study and were responsible for the design and development of the data analysis. JEO and IPN were responsible for data collection and analysis and also for data interpretation. AO and OIA contributed to the literature review section and references.

Disclosure Statement
The authors have not any competing financial, professional, or personal interests from other parties.

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Appendix

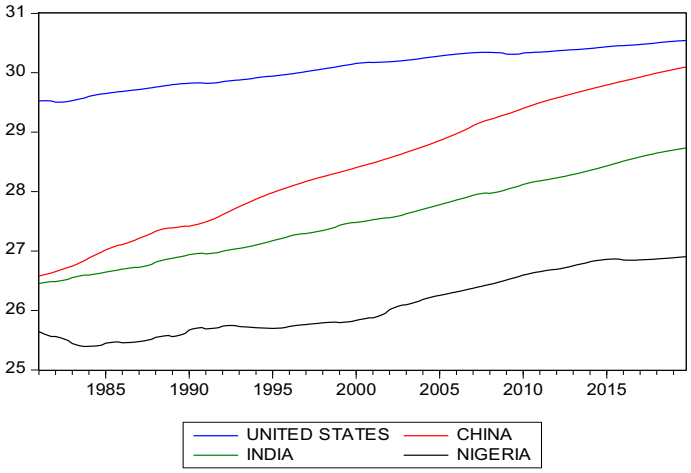

Figure 3 Graphical Representation of the Studied Economies
Source: Self research.