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New Insights into Export-growth Nexus: Wavelet and Causality Approaches

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

It is observed that exports play a significant role in economic expansion. Thus, this study tends to shed more light on the export and economic growth interaction in Nigeria using data between 1981 and 2018. Due to inconclusiveness in the literature, this study employs a more superior econometric technique to ascertain this link. Econometrics techniques utilized include ARDL, Toda Yamamoto causality, variance decomposition and wavelet coherence techniques. Findings from the study show; (i) there is cointegration among the variables utilized; (ii) there is evidence of synchronization hypothesis; (iii) gross capital formation, gross domestic savings, and export have a positive and significant impact on economic growth with foreign direct investment having an adverse effect; (iv); unidirectional causality was found running from gross capital formation, gross domestic savings and foreign direct investment to economic growth; (v) the wavelet coherence approach provide a supportive evidence for the ARDL and causality tests; and (vi) economic growth can predict a significant variation in export in the tenth year. Various recommendations were suggested based on these findings.

Keywords: Export; economic growth; wavelet approaches.

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1. INTRODUCTION

Over the past five decades, there has been a serious interest in the relationship between export and economic growth. This is a result of the economic expansion of the four Asian Tigers[1] between 1960 and 1990. During this period, they experience a constant high growth rate of 7% annually leading to the question of whether the economy is driven by export or vice versa. This issue is crucial in the context that identifying the causality between export and growth has a significant influence on the decision of policymakers on the correct strategies and policies to be pursued for economic growth and development. Nigeria's economy was largely an agricultural economy before the oil boom in the early 1970s and the overwhelming portion of its foreign exchange stemmed from the selling of cash crops including cocoa, coffee, palm produce, cotton, solid minerals, and groundnut.

With oil discovery, agriculture was relinquished to the second source of foreign exchange behind crude oil. Nigeria, an emerging economy, utilized many policy initiatives including the Import Substitution Industrialization Strategy (ISI), a campaign geared at swapping imported products with those manufactured domestically. Nigeria embraced the import substitution strategy in the 1970s in its search for economic growth and development, however, this strategy did not work because of many factors including lack of local technological capability, lack of local industrial manpower, and poorly written technological agreement [1]. This made Nigeria adopt the export-driven economic growth just like the four Asian Tigers due to similar socio-demographic, socio-economic features similar to them.

This gave birth to the Export Promotion Council by Act No 41 of 1988, thereby putting different incentives schemes on export to encourage non-oil exports for the sole aim of diversification of the production base of the economy, and decrease over-dependence on earning from crude oil which can expose the Nigerian economy to oil price fluctuations in the global market. The engine room of Nigeria's total export is the exports of oil and gas, accounting for 91% of total exports in Nigerian 2014. Nigeria main buyers of oil and gas are Europe which bought 43% of total oil exports in 2014, followed by 28% to Asia, 13% to America, and the remaining 13% for Africa countries [2].

In 2019, Nigeria recorded its highest non-oil export revenue which stood at $10.4 billion the highest since 2008 while total exports was $64.9 billion [3]. Therefore, oil revenue as a percentage of total exports decreases to 83.9% as against over 90% in past years for the first time [3]. In spite of the rise in Nigeria's total export earnings, over the years, the nation has been confronted with a substantial amount of balance of payment deficit. It is therefore crucial and worth exploring whether growth in export will enhance economic growth to help lower this deficit, and also whether there is a causal interaction between exports and economic growth in Nigeria.

Many studies have been carried out concerning export and economic growth in Nigeria [2], [4], and [5]. However, they found mixed results. Thus, due to the inconclusiveness in their study, this paper tends to shed more light on the topic in Nigeria by using more recent econometrics techniques. The subsequent segment of the article is as follows. The second segment presents a synopsis of the study. The third segment discusses the model, data and methodology. The fourth segment presents the result of wavelet coherence, ARDL, Toda Yamamoto Granger causality and variance decomposition. The last segment portrays the conclusion and the recommendations.

2. SYNOPSIS OF STUDIES

In the empirical literature, many studies have explored causal link between export and economic growth. Although, findings based on these studies revealed inconclusiveness as a result of dissimilar techniques utilized, timeframe, frequencies of data, and country(s) attributes. Hence, the link between exports and economic growth remains inconclusive and warrant further studies. Four various strands of the hypothesis are found on the interaction between export and growth namely; (a) export-led growth hypothesis, (b) growth-led export hypothesis, (c) synchronization hypothesis and (d) neutrality hypothesis.

The export-led economic growth hypothesis depicts a unidirectional causality from export to growth [6,7,8,9,10,11,12]. Growth-led export illustrates on one-way causality moving from economic growth to export [1,13,14]. The neutrality hypothesis signifies that export and growth does not have any significant causal interaction with each other [4,15,14,16,13]. The

[1]*Hong Kong, Singapore, South Korea and Taiwan.*

last hypothesis is the synchronization hypothesis which indicates that export and GDP growth have causal interaction with each other [17,9,5,6]. Table 1 depicts the summary of the empirical studies.

2.1 Research Contribution

Firstly, most previous studies fail to utilized variance decomposition in their analysis to explore the strength of the causal interaction between variables and to verify the efficacy causal impacts ahead of timeframe utilized. Secondly, this paper is different from previous studies that investigate this interaction because the research utilizes recent techniques in engineering and physics known as wavelet coherence techniques. The Wavelet coherence approaches have been utilized in econophysics to explore causalities between financial and economic variables. Nevertheless, this paper is the first to employ it to explore the causal link between economic growth and exports in the case of Nigeria. Lastly, wavelet coherence technique provides a supportive evidence for the ARDL and causality tests.

3. DATA, MODEL AND METHODOLOGY

3.1 Data and Model

The theoretical framework of this research is premised on Keynes's (1939) work on an open economy. The nation income based on his work is illustrated in equation 1 below.

$$Y = C + I + G + (X - M) \quad (1)$$

Where; national income (GDP growth) is denoted by Y, investment (gross capital formation) is represented by GCF, G mirrors government spending, and X-M represents foreign exchange.

Keynes [23] maintained that when export increase, there will be a multiplier effect which is positive on national income.

$$Y = f(X) \quad (2)$$

In the equation above, X stands for export, and Y economic growth.

Furthermore, FDI, GCF, and GDS are included because they are considered as a vital determinant of growth. The economic function for the model is depicted in equation 3 below;

$$y = f(X, GDS, GCF, FDI) \quad (3)$$

The study econometric model is depicted in equation 4 by taking the natural log of all the variables.

$$Y_t = \delta_0 + \delta_1 X_t + \delta_2 GDS_t + \delta_3 GCF_t + \delta_4 FDI_t + \varepsilon_t \quad (4)$$

where log of GDP growth is illustrated as Y, X mirrors log of exports, GDS illustrates log of gross domestic savings, GCF stands for log of gross capital formation, FDI denotes log of foreign direct investment, and ε describes the error disturbance.

3.2 Econometric Methodology

This study utilized five steps in the empirical analysis. Firstly, the stationarity test of the variables utilized is investigated. Secondly, the existence of short and long-run interaction is tested. Thirdly, the wavelet coherence technique was utilized to examine the correlation and causal effect between GDP growth and other independent variables. Fourthly, the Toda Yamamoto causality test was utilized as a robustness test for the wavelet technique. Lastly, the variance decomposition technique was utilized to predict the relative strength of causality between two variables beyond the time selected. To illustrate the short and long interaction among the variables, this study utilized the ARDL technique to cointegration created by [24]. This method has many advantages over most of the conventional techniques which is stated in most literature in econometrics. The error correction model is incorporated in the ARDL model. Thus, the long and short-run interaction among the variables are depicted in equation 5 below:

$$\Delta Y_t = \delta_0 + \sum_{i=1}^{l} \delta_{1i} \Delta Y_{t-i} + \sum_{i=1}^{l} \delta_2 i \ \Delta X_{t-i} + \sum_{i=1}^{l} \delta_3 i \, \Delta GDS_{t-i} + \sum_{i=1}^{l} \delta_{4i} \ \Delta LGCF_{t-i} + \sum_{i=1}^{l} \delta_{5i} \ \Delta FDI_{t-i} + \varpi ECT_{t-1} + \ \varepsilon_{t-i} \quad (5)$$

Where **Δ** mirrors the first difference operator, δ_0 stands for the constant term, $\delta_1, \delta_2, \delta_3, \delta_4, and\ \delta_5$ are short-run elasticities in regards to the independent variables, ARDL model lag order is illustrated by í, an error correction term is illustrated by ϖECT_{t-1} , ε_t signifies the error disturbance and time is represented by t.

Furthermore, the study utilized the FMOLS, and DOLS as a robustness test for the ARDL cointegration approach.

This study also explores the time-frequency dependence of Y, X, GDS, GCF, and FDI in Nigeria by utilizing the wavelet approach which was introduced by [23]. Non-stationarity is the major attribute of most variables that are utilized in economic or finance based research, thus estimating time-domain causality bias and unacceptable. Furthermore, if the time series data experience a structural break(s) time-domain causality tests with parameters fixed will probably suffer. On the other hand, the "standalone frequency domain approach major problem, is specifically known as the Fourier transform, which is emphasizing on the frequency domain that lead to complete omission of information from the domain" [25]. This problem is avoided in our estimation by employing a wavelet-based Granger causality test. The vulnerability in the Y, X, GDS, GCF, and FDI in Nigeria is captured by wavelet power spectral.

The below equation depict the Morlet equation which is the first equation of these techniques.

$$\varpi(t) = \pi^{-\frac{1}{4}} e^{-i\varpi t} e^{-\frac{1}{2}t^2} \tag{6}$$

where, ϖ mirrors frequency used on the restricted time series; p(t), n = 0, 1, 2, 3…….N-1; and $\sqrt{-1}$ is illustrated by i. Time series are transformed into the time-frequency domain which leads to transformation in wavelet. ϖ is changed, hence, evolved into $\varpi_{k,f}$. The below equation explain this transformation:

$$\varpi_{k,f}(t) = \frac{1}{\sqrt{h}} \varpi\left(\frac{t-k}{f}\right), \quad k, f \in \mathbb{R}, f \neq 0 \tag{7}$$

where k stands for the time and place whereas *f* depicts thefrequency. Kirikkaleli, & Gokmenoglu [26] pinpoint that the major parameters are k and f when utilizing the wavelet techniques. Thereby, revealing the time-frequency connection where the major factor is the continuous wavelet transition (CWT). Therefore, to link these two time series indicators together utilizing the CWT approach is important. The CWT is represented by equation 8 below.

$$\varpi_p(k,f) = \int_{-\infty}^{\infty} p(t) \frac{1}{\sqrt{f}} \varpi\left(\overline{\frac{t-k}{f}}\right) dt, \tag{8}$$

The transformation of the previous time is represented by p(t), and ϖ stands for the coefficient. This is summarized by the equation below;

$$p(t) = \frac{1}{C_\varpi} \int_0^\infty \left[\int_{-\infty}^{\infty} \left| \mathrm{w}_p(a,b) \right|^2 da \right] \frac{db}{b^2} \tag{9}$$

The wavelet power spectrum (WPS) variance[2] of the time series is represented by equation 10;

$$WPS_p(k,f) \left| W_p(k,f) \right|^2 \tag{10}$$

Kirikkaleli [27] noted that the cross-spectrum ratio to each spectrum of time-series by merging their frequencies is calculated by the Wavelet Coherence (WTC). The two time series wavelet transformation is depicted below;.

$$W_{pq}(k,f) = W_p(k,f)\overline{W_q(k,f)} \tag{11}$$

The CWT of p(t) and q(t) is depicted by $W_p(k,f)$ and the value of squared WTC is illustrated by $W_q(k,f)$. $R^2(k,f)$. This is summarised by the below equation;

$$R^2(k,f) = \frac{\left| S\left(f^{-1} W_{pq}(k,f)\right) \right|^2}{S\left(f^{-1}\left|W_p(k,f)\right|^2\right) S\left(f^{-1}\left|W_q(k,f)\right|^2\right)} \tag{12}$$

Zero (0) correlation between two series will surface if the $R^2(k,f)$ gets closer to 0 whereas correlation will show whenever $R^2(k,f)$ is close to 1, which spherical thick black line illustrates and also indicated by warmer color (red). However, The $R^2(k,f)$ values did not provide information about the interaction sign. Thus, a procedure which can identify Wavelet coherence by employing differences through deferrals indications in two time series wavering is suggested by [28]. Wavelet coherence at the difference phase is depicted in the below equation:

[2] *Variance is denoted as frequency function.*

$$\phi_{pq}(k,f) = \tan^{-1}\left(\frac{\mathrm{L}\left\{S\left(f^{-1}W_{pj}(k,f)\right)\right\}}{O\left\{S\left(f^{-1}W_{pj}(k,f)\right)\right\}}\right) \quad (13)$$

L and O reflect nn imaginary operator and a real part operator correspondingly.

Although the ARDL approach determines the interaction between variables, but not the causality direction of variables. Therefore, the causality test suggested by Toda Yamamoto [29] was utilized by this study to capture the direction of causality. Though there are other causality techniques available, the Toda Yamamoto technique was utilized because it makes inference correct even when the indicators are integrated of different orders. The fundamental notion of this technique is to artificially augment the correct order of VAR.

The general form of the Toda Yamamoto causality for is illustrated by equation 14 & 15 below.

$$S_t = \alpha_o + \sum_{i=1}^{m} \alpha_i S_{t-1} + \sum_{i=m+1}^{m+dmax} \alpha_i S_{t-1} + \sum_{i=1}^{m} \beta_1 T_{t-1} + \sum_{i=m+1}^{m+dmax} \beta_1 T_{t-1} + e_t \quad (14)$$

$$T_t = \alpha_o + \sum_{i=1}^{m} \alpha_i T_{t-1} + \sum_{i=m+1}^{m+dmax} \alpha_i T_{t-1} + \sum_{i=1}^{m} \beta_i S_{t-1} + \sum_{i=m+1}^{m+dmax} \beta_i S_{t-1} + \mu_t \quad (15)$$

Where S, and T mirrors the variables, and α's and β's are indicators of the framework. Also, Dmax is the maximum integration order that the system is presumed to have; μ_t and ε_t are the residuals of the model. Implementation of the procedure involves two steps. firstly, it involves the evaluation of the lag length (m) and secondly, picking the maximum integration order (dmax) for the system variables. Measures such as the AIC, SC, FPE, and HQ are employed in the determination of the lag order of the VAR.

Table 1. Summary of literature

Investigator (s)	Country (s)	Techniques used	Period	Findings
Wadud [18]	Pakistan	Cointegration & ECM	1978-1998	Growth led Export Hypothesis
Shirazi & Manap [6]	Pakistan	ARDL Bounds, TYGC	1960-2003	Export-Led Growth IMP↔Y
Awokuse [17]	South Korea	VAR, TYGC, VECM	1963–2001	Synchronization hypothesis FDI→Y INV→EMP
Shirazi & Manap [19]	Five South Asian countries	ARDL Bounds & multivariate Granger causality	1960-2000	Synchronization hypothesis Was found in Pakistan, Bangladesh, & Nepal IMP→Y
Kónya [20]	24 OECD Nations	Granger causality	1960-1997	Exports-led growth Neutrality Hypothesis
Tang [21]	Hong Kong	Granger causality	1984-2003	Neutrality Hypothesis
Jordaan & Eita [22]	Namibia	Bounds & Pairwise Granger	1970-2005.	Export-Led Growth
Jordaan & Eita [7]	Botswana	Pairwise Granger Causality	1996-2007	Synchronization hypothesis
Alimi & Muse [1].	Nigeria	Johansen cointegr & Granger Causality	1970-2009	Growth led Export Hypothesis

Investigator (s)	Country (s)	Techniques used	Period	Findings
Okodua & Ewetan [4]	Nigeria	OLS, Granger Causality	1970-2010	Growth-led-export
Tahir et al [16]	Sri Lanka	Johansen cointegr & Pairwise Granger Causality	1981-2012,	Neutrality Hypothesis IMP↔INV IMP→EMP
Gokmenoglu, et al., (2015)	Costa Rica	Johansen cointegr & Granger Causality	1980-2013	Export-Led Growth
Lam, (2016)	4-ASEAN	cointegration, & ECM	1985-2014	Synchronization hypothesis
Kalaitzi & Cleeve [14]	Slovakia	ARDL Bounds, TYGC	1997Q1-2014Q4	Growth led Export Hypothesis
Ali & Li [11]	China & Pakistan	ARDL Bounds, ARDL, TYGC	1980-2015	Exports-led growth X→IMP
Yusoff [9]	Malaysia	Johansen cointegr. VECM, & Granger& TYGC	1980-2012	Exports-led growth FDI→Y GOV→Y
Faisal et al [10]	Saudi Arabia	ARDL-bounds, Granger causality	1968-2014.	Exports-led growth X→IMP
Kim et al [12]	Myanmar	Johansen cointegr, & TYGC	1981 to 2015	Exports-led growth
Abosedra & Tang [15]	MENA Region	Granger causality	1980Q1-2012Q4	Neutrality hypothesis
Aluko & Adeyeye [13]	41 African Economies	BC Granger causality	1995-2018	Neutrality hypothesis, Synchronization hypothesis, & Growth led Export Was found amog the countries
Kalaitzi,& Chamberlain (2020)	United Arab Emirates	DOLS, VECM, multivariate Granger causality	1975–2012	Neutrality hypothesis
Zoramawa et al [5]	Nigeria	ARDL bound, Granger Causality	1981-2019.	Synchronization hypothesis

TYGC: TodaYamamoto Granger Causality, INV; Investment, VECM: Vector Error Correction Model, IMP: Import, ARDL: Autoregressive Distributed Lag, Y: GDP Growth, GOV: Government Expenditure,and X: Exports; Source: Investigator Compilation

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

This study utilizes yearly data for GDP per capita (Y), exports (X), gross capital formation (GCF), gross domestic savings (GDS), and foreign direct investments (FDI) which are measured in real nominal terms stretching between 1981 and 2018. Exports, and GDP growth between 1981 and 2018 are depicted in Figs. 1 and 2 respectively.

The Table 2 illustrates the descriptive statistics of the variables (Y, X, GCF, GDS, & FDI) utilized by describing their characteristics. The ranges for Y, X, GCF, GDS, and FDI are 2.43 to 3.50, 9.45 to 10.87, 9.98 to 10.87, 13.23 to 13.79, and 8.27 to 9.94 respectively. The variables normal distribution is illustrated by Kurtosis, Jarque-Bera, and skewness. For data to mirror normal distribution, the skewness must be close to 0. Hence, all the variables show characteristics of normally distributed based on this. Furthermore, the value of kurtosis must not be more than 0 to mirror normal distribution. Based on this, all the variables are normally distributed. The probability values of the Jarque–Bera statistic as observed from the table illustrates that variables utilized are distributed normally.

4.2 Unit Root Tests

Integration order of variables utilized were tested by Utilizing the ADF test by Dickey & Fuller [30], PP test by Phillips and Perron [31] and KPSS by Kwiatkowski et al [32]. It is essential to conduct this test to determine the order of integration of the variables utilized. Deploying the ARDL bounds test requires the dependent variable (Y) to be I(I). Since the indicators integrated at a mixed level i.e. I(0) and I(I), the ARDL bounds test is suited to analyze the cointegration among the variables in the long-run. Tables 3 illustrate the stationarity level of the variables at a trend and intercept.

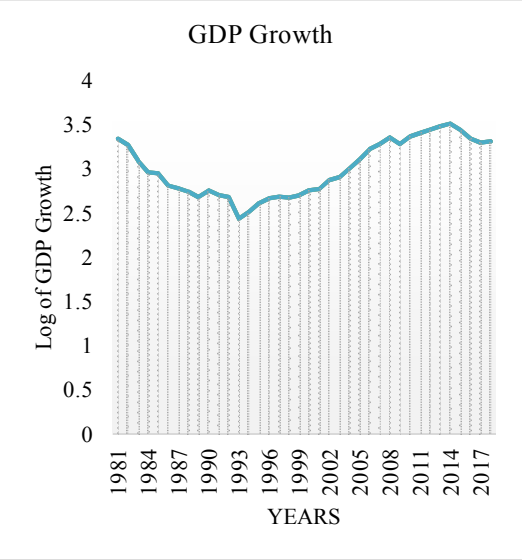

Fig. 1. GDP growth between 1981 & 2018

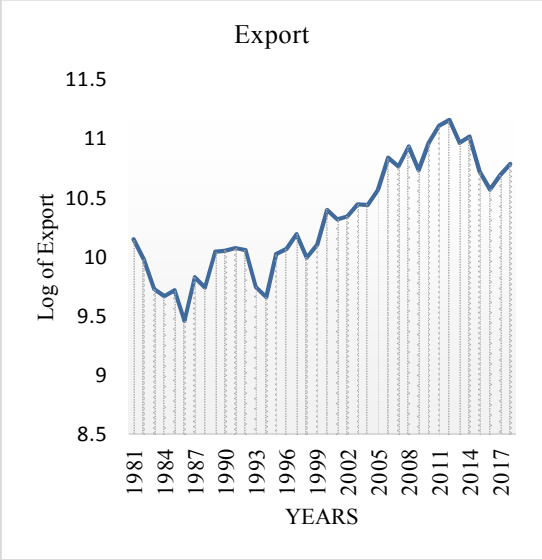

Fig. 2. Export between 1981 & 2018

Table 2. Descriptive statistics

Source	World Bank Database	Central Bank of Nigeria	World Bank Database	Central Bank of Nigeria	Central Bank of Nigeria
Variables code	Y	X	GCF	GDS	FDI
Mean	3.0019	10.319	10.432	13.511	9.1618
Median	2.9505	10.256	10.284	13.452	9.2008
Maximum	3.5082	11.161	10.872	13.792	9.9465
Minimum	2.4317	9.4589	9.9811	13.234	8.2768
Std. Dev.	0.3192	0.4743	0.2807	0.1921	0.5067
Skewness	0.0621	0.1224	0.3791	0.1760	-0.0123
Kurtosis	1.5735	1.8578	1.6358	1.3842	1.7467
Jarque-Bera	3.2463	2.1605	3.8569	4.3296	2.1605
Probability	0.1972	0.3395	0.1453	0.1147	0.3395
Observations	37	37	37	37	37

Table 3. Unit root test (K & T)

Variables	ADF	Decision	PP	Decision
Y	-4.50*	I(1)*	-4.47*	I(1)*
GCF	-4.01**	I(0)**	-4.13**	I(0)**
GDS	-6.41*	I(1)*	-6.40*	I(1)*
X	-7.50*	I(1)*	-8.49*	I(1)*
FDI	-9.82*	I(1)*	-9.92*	I(1)*

*Note: *, ** & *** signifies 0.01, 0.05, and 0.10 level of significance respectively. K. and K. & T indicate constants and constant and trend*

4.3 ARDL Analysis

Table 5 depicts the findings of the ARDL bounds test. The table display cointegration in the long run among the variables utilized. Furthermore, based on the diagnostic test, it is clear that the model did not violate any assumption of the regression model.

After the cointegration is ascertained among the variables, the next thing is to verify the long-run interaction between the variables. This long-run estimate is carried out with the aid of ARDL techniques. Also, the Fully modified OLS, and dynamics OLS were utilized as a robustness test for the ARDL technique. Table 6 displays the outcome of the ARDL, FMOLS, and DOLS. Based on the estimation, when other thing remains constant, a 1% rise in export will result in a 0.28% increase in GDP growth. keeping other factors constant, a 1% increase in GCF leads to 0.32% in GDP growth. Furthermore, a 0.57% increase in GDP growth was caused by a 1% rise in GDS, and a 1% increase in FDI cause GDP growth to decrease by 0.12%. Table 7 display the short-run dynamics. As expected, the ECM coefficient is correct and significant, therefore there is supportive proof of a stable relationship in the long run among the variables utilized. This coefficient signifies that a deviation from equilibrium in the long-run output level in one year is adjusted by 24% over the subsequent year. The elasticity of GDP growth concerning exports and GCF is positive and significant in the short run, thus contributing to economic growth.

Table 4. ARDL cointegration and diagnostic tests

Panel A: ARLD Cointegration Test		
Function	Y=F(X, GCF, GDS, FDI)	
Lag structure	2, 4, 3, 2, 4	
F-stat	8.2674*	
	Lower Bound	**Upper Bound**
10%	2.45	3.52
5%	2.86	4.01
1%	3.74	5.06
Panel B: Diagnostic Tests		
Normality (V)	1.521(0.43)	
Heteroscedasticity (I)	1.054 (0.45)	
Breusch–Godfrey LM test (C)	0.9174(0.42)	
Ramsey Test (K)	0.949(0.34)	
Stability Test (Y)	CUSUM & CUSUM of Square are stable at 5% level	

*Note: * stands for 1% significance levels*

Table 5. Long-Run estimate

Regressors	**Dependent variable: Y**					
	ARDL		**DOLS**		**FMOLS**	
	Coefficient	**t-stat**	**Coefficient**	**t-stat**	**coefficient**	**t-stat**
X	0.2809	3.165*	0.2809	3.447*	0.2857	7.148*
GCF	0.3226	2.722**	0.3226	2.964**	0.3085	5.440*
GDS	0.5788	-1.102***	0.5788	2.085**	0.5927	2.168**
FDI	-0.1284	-2.329**	-0.0753	-2.010***	-0.0798	-4.285*
Constant	-4.4059	-2.378	-4.4059	-2.590	-4.3189	-5.176

*Statistical significance at the 1%, 5%, & 10% is depicted by *, **, *** respectively*

Table 6. Short-Run estimate

Regressors	**Dependent variable: ΔY**		
	Coefficient	**t-stat**	**Prob**
ΔX	0.2809	4.7112	0.000*
ΔGCF	0.2822	2.7619	0.015**
ΔGDS	-0.5788	-0.2947	0.823
ΔFDI	-0.1070	-3.2963	0.000*
ECM (-)	-0.2440	-7.2902	0.000*

*Statistical significance at the 1%, 5%, & 10% is depicted by *, **, *** respectively*

Findings from this study revealed that exports significantly influence the GDP growth of Nigeria, both in the long and short run. This outcome is in line with some studies [10,14,11,12]. Furthermore, gross capital formation significantly impacts growth positive which concurs with some studies [17,33,34]. Additionally, an increase in GDP growth is a result of gross domestic savings hence positive and statistical link exists between them. This finding agrees with some studies [35,36,37]. findingscomply with this finding. Finally, there is a negative and statistically significant link between foreign direct investment and economic growth. This outcome aligns with some studies [38,39] though, it is not consistent with some studies [40,41,42]

4.4 Wavelet Coherence Result

The wavelet approach (WTC)[3] is a modification of XWT. Figs. 3, 4, 5 and 6 depict the findings (i) wavelet coherence between GDP growth and gross capital formation, and (ii) GDP growth and exports, (iii) GDP growth and foreign direct investments; and (iv) GDP growth and gross domestic savings respectively. In Figs. 3, 4, 5 and 6, the grey cone signifies the cone of influence which will be utilized for interpretation whereas the significance level which is depicted by the thick black line is calculated based on the Monte Carlo simulations. Additionally, when the correlation is weak between two indicators, it is depicted by colder colors (blue) while warmer color (red) illustrates a strong correlation between the two variables. Rightward arrows illustrate positive interaction between the two indicators while negative interaction in denoted by leftward arrows. Additionally, when the arrows point rightward and up, or leftward and down, it shows that second variables cause the first variable. Thus, the second variable causes the first variable. Also, if the arrows point leftward and up or rightward and down, it shows that the first variable cause the second variable.

Fig. 3 shows the wavelet coherence between economic growth and export in Nigeria from 1981 to 2018. At various scales, there are rightward arrows which indicate that there is a positive correlation between GDP growth and exports from 1993 to 2019. Furthermore, the arrows are rightward up and rightward down which indicates a bidirectional causality between GDP growth and export. Fig. 4 mirrors the wavelet coherence between economic growth and gross capital formation. On a different scale, there are rightward arrows between 1981 and 2018 which denotes evidence of a positive relationship between GCF and GDP growth. the rightward and up arrows also signify that GCF leads to GDP growth that is gross capital formation causes GDP growth. Fig. 5 denotes the wavelet coherence between economic growth, and GDS between 1981 and 2018. At scale 2-8, there is evidence of positive interaction between GDP growth and GDS as depicted by the rightward arrows. The rightward and up arrows show that GDS lead to GDP growth that is GDS cause GDP growth. Fig. 6 represents the wavelet coherence between GDP growth and FDI between 1981 and 2018. The leftward arrows indicate a negative correlation between FDI and GDP growth between 1985 and 2000 at scale 6-11. The leftward and down arrows give a shred of supportive evidence that FDI leads GDP growth which implies that FDI causes GDP growth.

4.5 Granger Causality Test

Toda-Yamamoto Causality test was utilized to examine causal interaction between Y and X, GCF, GDS, and FDI in Nigeria. Table 8 reveals the outcome of the Toda-Yamamoto test. The findings revealed a bidirectional causality between GDP growth and export which give support for the synchronization hypothesis for Nigeria. Furthermore, there is a one-way causality running from GCF, GDS, FDI, to GDP growth in Nigeria. This finding shows that all the variables employed in this paper are important determinants of economic growth in Nigeria.

4.6 Variance Decomposition Analysis

One of the major drawbacks of the causality test is the inability to predict the relative strength of causality between two variables beyond the timeframe utilized. As a result of this, the result of the causal interaction is weakened. Thus, the variance decomposition is utilized in this study to explore the strength of the causal interaction between variables and to verify the effectuality of causality impacts ahead of timeframe used.

[3] *To address the shortcoming posed by XWT, the WTC seems much more suitable. For instance, shortcomings like wavelet power spectrum which is not standardized and utilized by the XWT. This indicates that, if one spectrum is locally, and the other shows peaks, confusing results will be produced by XWT. Furthermore, false interactions are produced by the peak relationship between variables that are not necessarily related.*

Table 7. Causality test

	Causality direction	Lag	Prob.
TodaYamamoto causality	Y → X	4	0.000*
	X → Y	4	0.000*
	Y → GCF	4	0.152
	GCF → Y	4	0.000*
	Y → GDS	4	0.245
	GDS → Y	4	0.000*
	Y → FDI	4	0.546
	FDI→ Y	4	0.025**

*Note: → stands for direction of the direction of causality, *, ** and *** mirror significance at 1%,& 5% levels, correspondingly. Optimal lag for the model has been selected using SC information criteria (Lag=4)*

Table 8. Variance decomposition

Variance Decomposition of Economic Growth						
Period	**S.E.**	**Y**	**X**	**GCF**	**GDS**	**FDI**
1	0.072757	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.097997	94.16452	0.366366	4.637740	0.017188	0.814185
3	0.117563	85.49647	0.507608	11.59649	0.024481	2.374949
4	0.136870	75.60928	0.939103	20.13678	0.284872	3.029970
5	0.156864	67.58840	1.540281	27.06549	0.613620	3.192202
6	0.175047	61.73522	2.233956	31.96685	0.928482	3.135500
7	0.190790	57.35247	3.060863	35.26487	1.255548	3.066242
8	0.204324	53.73552	3.970423	37.69030	1.611137	2.992616
9	0.216008	50.70427	4.953629	39.45996	1.952516	2.929622
10	0.225991	48.16390	5.971442	40.73808	2.250901	2.875679
Period		**Variance Decomposition of Export**				
1	0.178175	41.03300	58.96700	0.000000	0.000000	0.000000
2	0.213457	45.09027	48.48160	3.599512	1.090994	1.737618
3	0.239329	40.11649	45.19027	8.725683	1.212345	4.755211
4	0.264462	35.49656	40.02455	17.63680	0.992972	5.849124
5	0.290914	32.47271	35.41252	25.25657	0.846467	6.011725
6	0.312309	30.70733	32.20101	30.52974	0.784582	5.777334
7	0.328386	29.53284	30.36329	33.72172	0.813276	5.568876
8	0.340423	28.46292	29.26081	35.96077	0.949743	5.365753
9	0.349561	27.55828	28.66994	37.43404	1.140088	5.197653
10	0.356278	26.81974	28.42801	38.35596	1.335660	5.060625

To verify the exact influence of the X, GCF, GDS, and FDI on GDP growth and influence of GCF, GDP growth, GDS, and FDI on X for a relatively long period, the variance decomposition for 10 consecutive periods are utilized. In the first period and second period, all of the variations in GDP growth is explained by its own innovations. With a standard error of 0.072, and0.097 respectively, GDP growth can describe 100%, and 94% of its own innovation. However, in the ninth and tenth period, gross capital formation can explain 39% and 40% of innovation in GDP growth which shows that it is a driver of GDP growth in Nigeria. Also, in the first period, variation in export growth can be explained by 58% of itself while 41% of the remaining variation can be explained by GDP growth. furthermore, in the second period, 48% of the variation in exports can be explained by 48% of itself whereas 45% can be explained by GDP growth. However, as the period dwindles, in the tenth period, variation in the exports can be explained by 28% of the variable itself while gross domestic formation and GDP growth can explain 26% and 38% of the variation in exports. This shows that GCF and GDP growth is an important driver of exports.

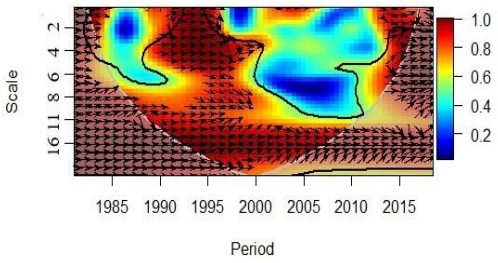

Fig. 3. WTC between Y & GCF

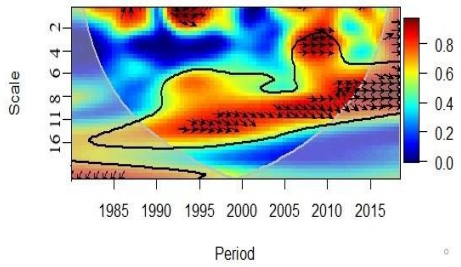

Fig. 4. WTC between Y & X

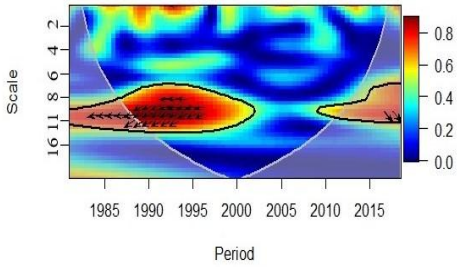

Fig. 5. WTC between Y & FDI

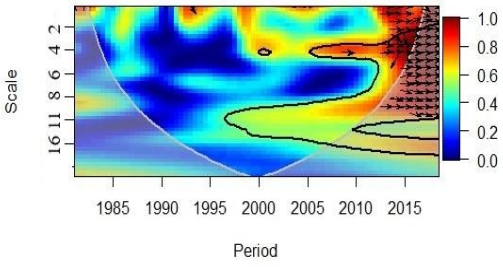

Fig. 6. WTC between Y & GDS

5. CONCLUSION AND RECOMMENDATIONS

The export and GDP growth interaction is an issue of discourse in the surviving pieces of literature. Due to inconclusiveness in the literature on this relationship in Nigeria, this study tends to shed more light on this interaction by utilizing yearly data spanning between 1981, and 2018. This study utilized the ARDL techniques to explore the short and long-run links between GDP growth, and export, gross capital formation, foreign direct investment, and gross domestic savings. Furthermore, the newly developed technique, namely, wavelet coherence was utilized to explore the co-movement and causal interaction between GDP growth, and export, gross capital formation, foreign direct investment, and gross domestic savings. The technique allowed us to explore data in the dimensional time-frequency sphere. In addition to this technique, the Toda Yamamoto causality test was utilized to investigate the causal interaction between GDP growth and other variables. Finally, the variance decomposition was utilized to explore the strength of the causal interaction between variables and to verify the effectuality of causality impacts ahead of time. Findings from the ARDL techniques show; (i) cointegration among the variables; (ii) there is a positive and significant relation between GDP growth and gross capital formation, export, and gross domestic savings; and (iii) FDI has a negative and significant link with GDP growth. Findings from the Toda Yamamoto causality test depicts; (i) bidirectional causality between GDP growth and export. This evidence also supports the synchronization hypothesis; and (ii) unidirectional causality running from gross capital formation, gross domestic savings, and foreign direct investment to GDP growth in Nigeria. The wavelet analysis result provides a shred of supportive evidence for the ARDL long-run estimate and Toda Yamamoto causality tests. Finally, the variance decomposition outcome shows (i) GDP growth can significant predict itself in the first and second period by 100% and 94%respectively, however, in the ninth and tenth year, gross capital formation can predict 39% and 40% of GDP growth; and (ii) export predict 48% of itself while economic growth predicts 41% of its variation. However, in the tenth year, gross capital formation, and GDP growth can predict 38%, and 26% of export respectively.

Based on these findings, the study suggested; (i) further liberalization of trade policy in favor of export expansion; (ii) Since there is a negative link between FDI and growth policy-makers in Nigeria should make policies that favor foreign investors to avoid fluctuation in FDI inflows; (iii) since increase in savings lead to investment thereby resulting to growth, interest rate should be structured in a way to stimulate savings.

Though empirical estimation of this research is solid by utilizing ARDL, FMOLS, DOLS, Toda

Yamamoto causality, variance decomposition and the newly developed wavelet coherence, more studies should be conducted in developed, and developing countries utilizing more variables that influence economic growth.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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