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Digital currencies and the Nigerian economy: Evidence from selected coins

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ABSTRACT: *This study emphasizes the implication of dynamic connection between digital currency and Nigerian economic growth rate by focusing attention on Bitcoin, Ethereum and Litecoin with respect to their returns and volatility from 2010Q4 to 2022Q3. As a way to have a robust estimation, we model our analysis using ARDL model and granger causality test. This model is rather useful to have both short and long run estimations. Importantly the study's outcome conforms with the fundamentals. By findings from the study, the trend analysis suggests that the country's exchange rate moves in line with digital currency activities while at the same time signifies some implication on the growth rate of the Nigerian economy. While lower returns for Bitcoin and Litecoin increase growth rate, the return for Ethereum rather move in the same direction as the growth rate. This indeed suggest that most Nigerians into digital currency activities often engage in portfolio diversification among available coins. The study further found that low volatility in the market will raise (significantly especially for Ethereum) growth rate of the economy while causal implication run from returns and volatilities of these coins to growth and exchange rates. Indeed, the findings have important policy implication for the Nigerian economy which suggests paying good attention to digital currency activities in the country and formulating necessary policies to improve it.*

Key Words: *Digital currency, Growth rate and ARDL, Volatility.*
JEL Classification: *E51; C53; O43; B41; C22.*

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1. Introduction

The need to have a private monetary system whose cost of production will be relatively low and at the same will ensure price stability was first discussed by Hayek (1976). At this time, most western countries experienced high level of price instability which was politically motivated and at the same became difficult to resolve by the monetary authority. This setback led to the suggestion by Hayek (1976). However, despite having potential to generate economic importance, the proposal failed to be prioritized (Fernández-Villaverde & Sanches, 2018). The renew interest for the alternative currency later arose in the 90s due to technological booms at that period and which led to the emergence of digital currencies like Flooz, Digi Cash and Beenz. According to Tong and Jiayou (2021), digital currency can be categorized into three on particular basis: Bitcoin and Ethereum; global stablecoins such as Libra and US Dollar Tether (USDT) and central bank–digital currency by central bank, CBDC. The Bitcoin and Ethereum are highly decentralized with unstable values. They are mostly being used for speculative purpose while stablecoins are relatively centralized and are backed by a system of algorithms. The CBDC as another form of digital currency enables the monetary authority to constitute a player in this privately-motivated currency creation system.

On the theoretical connection between digital currency and the growth of economy, various questions have been raised and the answers are being offered. In particular, it becomes a necessity to raise concern about the stability of digital currency, its co-existence with fiat money and the efficiency of its allocation (Fernández-Villaverde & Sanches, 2018). However, while theoretically price stability is possible under this arrangement, its efficient allocation and prudent monetary control remain greater issues of concern. Although, through technological development, digital currency creation becomes very easy and this rule out the possibility of transaction cost by the third party, the fact that some individuals with dubious mind can easily drive it to their private advantage needs to be resolved. However, with higher participants who are of trust minds, it becomes very difficult for the system to be hijacked by any hackers. At worst, such an individual can only do such to a limit of double spending and not to the detriment of the entire system (Nakamoto, 2008). Despite this, issue surrounding this money creation with respect to digital currency require serious understanding and which can be better achieved through empirical analysis.

Moreover, there have been series of empirical findings on digital currency and financial market analysis nexus (Bašta & Molnár, 2018; Uzonwanne, 2021). Some other studies have been evolved to estimate the connectivity between digital currency and economic policy uncertainty (Yen & Cheng, 2021). Given the role of oil in the production of cryptocurrency, studies have further account for the possible impact of oil price on the production of bitcoin (Li, Hong, Wang, Xu, & Pan, 2022; Salisu, Ndako, & Vo, 2023). However, this present study is not particularly concern to go into this direction but rather to take the research focus to country-level analysis. Essentially, this present research will take consideration on the Nigerian economy by focusing on the possible impact of the adoption of digital currency on the economic performance in Nigeria. Studying digital currency with respect to Nigerian economy is considerably a necessity as Nigeria takes top 5% of coin holders in the entire globe. Hence, activities relating to digital currency will be implicative of the local economy.

It is equally worthy to note that studies on the impact of digital currency on economic growth, particularly for Nigeria is not unavailable (for example (Ekong & Ekong, 2022; Safiyanu, Haruna, Gurin, & Bayero, 2022)). While some these studies focus on the implication of digital currency for financial inclusion (as in Ekong and Ekong (2022)), digital currency and exchange rate (Safiyanu et al., 2022) and connectivity of digital currency and monetary policy with economic growth using Structural Vector Autoregressive (SVAR) model (Ahannaya, Oshinowo, Sanni, Arogundade, & Ogunwole, 2021), there have not been serious attention on the wider implication of digital currency for the Nigerian economic performance. As a way to fill this gap, this study will carry out an indebt analysis on this nexus with further evaluation on both short run and long run impact. In addition, trend analysis with respect to this variable will be aligned with various economic policies that have taken place in the countries right after the emergence of digital currency.

To further deviate from the research focus of the prior studies, the study gives consideration to three main digital currencies which are Bitcoin, Ethereum and Litecoin. The three currencies represent more than half of trade volume in this market. In another angle, unlike other studies which have either use bitcoin volatility (Safiyanu et al., 2022) or market capitalization of CBCD), this study shall in addition to returns, utilize market volatilities in analyzing its impact. As a way to measure its impact on economic performance, the focus shall be on exchange rate and growth rate. Study that has looked into this direction by examining the impact of cryptocurrency on economic growth using growth and exchange rates is very scarce. In particular, transactions through cryptocurrencies are more inclined to have impact on not only exchange rate but also the growth rate of the economy. This is rather necessary as acceptance of digital currencies for transaction purpose cut across the world. In essence, the researcher's investigation is very crucial to fill the vacuum created as a result of scanty of literature in this area.

While the main focus of this study is to investigate the impact of digital currencies on the economic growth rate of Nigeria, it is really a necessity as the volume of currency in an economy has some known implication for the output growth. Since digital currency facilitates trading activities and are used to carry out many online transactions, its potentiality in driving output growth is rather not surprising. Thus, the outcome from the findings will be highly crucial for various stakeholders such as government agents, private individuals and policy makers. Meanwhile, following the emergence of digital currency in 2008 (Nakamoto, 2008), its growing level raises concern for the monetary authority on possible implication for the economy. There have been numerous monetary policies that have been put in place. Some of these policies have some implications for the growth or for the functionality of volume of money in circulation. The growth in volume

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of money with simultaneous co-existence with digital currency could have wider implication as regard their trend and pattern. The knowledge on this pattern will be highly crucial for the monetary authority. In particular, the implication for the co-movement of digital currency, change in the volume of fiat money and the need for implementation of cashless policy will be revealed by this study.

Another major concern on the nexus between digital currency and economic performance is on the dynamic relationship. Ideally, understanding the impact in both short and long run is very crucial. With Autoregressive Distributed lag (ARDL) model which this study employs, analysis relating to short run implication will be easily evaluated. In addition, the long run impact will equally be revealed. The possibility of breaking point in the data composition can be modelled alongside the analysis. Despite numerous studies in this area, those that have paid attention on the examination of short and long run impact are very scare in the literature (Corelli, 2018; Riska Dwi & Nadia, 2019). Also, digital currencies have been categorized as either centralized or decentralized currency. Centralized digital currencies are known to exhibit unstable features in its prices, returns and volatilities. Specifically, Bitcoin has not been stable over time. In 2009 only 50 units of bitcoin was reported while it increased to more than 17 million in 2017. At the same time more businesses are now giving it more recognition and number of people who owns it has also surpassed 10 million (Salisu et al., 2023). At the same time its price has not been stable. In recent time, the price of bitcoin rises to over 26600 USD in June, 2022 while it falls to around 20270 USD around march, 2023. This same trend is also applicable to Ethereum and Litecoin. Thus, examination of their volatilities, volume and capitalization with respect to economic performance is necessary.

After this introduction, the next section present literature review and this is followed by section on framework and methodology. The study further present data and summary statistics in section 4 while attention in section 5 gives focus to stylized facts about the trends of the variables of choice. The result analysis is presented in section 6 while section 7 concludes b giving appropriate recommendation and area of future study.

2. Brief Literature Review

In the recent time, there have been vigorous attempts on the possible implication of digital currencies on not only the macroeconomic policy of government but also on the possible impact on the economic performance. In an extensive analysis, Aminu, Hayewa, Mohammed, and Abubakar (2022) investigated the connectivity between digital currency, monetary policy and economic growth in Nigeria in the period between 2013 quarter 1 to 2020 quarter 4. The approach for analysis was structural vector autoregressive method where initial preliminary statistics was carried out to ensure proper specification of the model. In the outcome of the analysis, while proxies for monetary policy have little impact on growth, that of digital currency has insignificant impact on the Nigerian economic growth. Specifically, the variance decomposition showed that money supply account for 41% in economic growth while that from digital currency can be technically sum to 0%. The study further made appropriate recommendations to support little implementation of monetary policy for the economy. Also, further implication about digital currency-growth nexus was analyzed in the study by Ozili (2022). In his analysis, he explained various advantages and disadvantages that are associated with Nigeria's Central Bank Digital Currency (CBCD). The study offered that while CBCD will improve transmission mechanism of monetary policy and further ensuring financial inclusion, the likelihood of being affected by data theft, hacking and digital illiteracy is very high.

However, Ekong and Ekong (2022) examined the impact of digital currency at ensuring financial inclusion for growth and development in Nigeria. The research used quarterly data range between 2006 and 2020. The study supported that the use of digital currency was very effective in raising the level at which people are involved in financial activities and at the same raising the level of development for the country. In all the study find about 7% cumulative effect of crypto transaction on the financial services in the country. In an earlier study by Ahannaya et al. (2021), attempt was made to examine the effect of cryptocurrencies on the economic growth for the case of Nigeria. The study applies quantitative data which was sourced through the use of structured questionnaire while the results revealed that the use of digital currency has positive implication on the Nigerian economy.in particular, about 52% variation in economic growth was explain by changes in cryptocurrency while the remaining48% was due to other factors. Further, it confirmed that a greater number of people now believe that digital currencies such Bitcoin, Litecoin, Ethereum are not only safe but also legitimate.

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The connection between cryptocurrency and exchange rate in Nigeria has further been established. Safiyanu et al. (2022) made use of Autoregressive distributed lag to estimate the effect of bitcoin prices on the exchange movement of Nigerian economy with monthly data spanning between January 2015 and December, 2020. In this study, it was established that volatility of bitcoin prices significantly has impact on the Nigerian exchange for short run and long run. While naira appreciated with higher prices of bitcoin, it depreciated with lower prices. The ECM term is found to be -0.5118 which gives an indication that about 51% of adjustment to equilibrium takes place every year. The postestimation statistics further confirm the robustness of the method of analysis. Chris, Ebere, Onyeledo, and Augusta (2021) further undertook a research evaluation on the effect of cryptocurrency on the Nigerian economy. In the study, primary data source was employed and it was revealed that online transactions were significantly improving, while the bitcoin and other digital currencies were becoming more acceptable in the country. People now globally see its usage as being safe, legitimate and save and is contributing positively to the growth of the economy. Holtmeier and Sandner (2019) also provided a comprehensive report on the potential ability of cryptocurrency to generate growth in developing countries. The study pointed out various advantages inherent in the usage of digital currencies which necessarily ensure trust among users with relatively low or no cost of transaction. Nevertheless, they underscored the likelihood of using the channel for illegal and fraudulent activities. In all, they emphasized the possibility of having increased human development index as a result of its usage thereby contributing to poverty reduction. By extension, they called for government control of the digital currency through a system of centralization and being geo-specific in its usage for transaction process. This according to them would serve as a way of reducing the rate of its volatility.

In a way to show the extent of regulatory challenges facing the adoption of cryptocurrency in Nigeria and its further implication on profitability of banking industry, Ojiakor, Ihegboro, and Onah (2022) used data on the year-to-year profit of First Bank Plc with the payment systems for Bitcoin, Ethereum, Litecoin and Bitcoin cash payment. According to the findings of the study, while bitcoin and bitcoin cash payment system significantly and positively influence the profitability of the sampled bank, the impact with respect to Ethereum and Litecoin payment system was found to be equally significant but negative. Despite several warning on the potential risks associated with investment in cryptocurrency, the study emphasized high level of trust that people place on the adoption of digital currencies with market size reaching $2 billion in the year 2021. The adjusted R square of the model is found around 0.56 which implies that about 56% of variation in the model is explained by the variables of model.

In an earlier analysis, Jimoh and Oluwasegun (2020) investigated the relationship between economic-financial variables and most traded cryptocurrencies which are Bitcoin and Ethereum for the Nigeria case. Monthly data from August 2015 to December 2019 was employed for the study. As for the techniques of analysis, Generalised Autoregressive Conditional Heteroscedasticity (GARCH 1,1), Exponential General Autoregressive Conditional Heteroscedasticity (EGARCH 1,1) and granger causality were used in various analyses where the reaction of exchange rate volatility and stock prices were established in relation to volatility of cryptocurrency prices. The results attribute instability of bitcoin and Ethereum prices to stock market price than exchange rate in Nigeria. Also, the result found evidence of unidirectional causality from Bitcoin and Ethereum to all share index. The volatility coefficient is found to be negative while validity persistence had magnitude of 0.70 which indicates that any volatility recorded in this system will continuously revert to the base line. Hence, they recognize the necessity to pay attention to movement of cryptocurrency prices in making investment choices. However, the present study will add to this existing body in the area that have earlier been explained.

3. Framework and Methodology

This study will give attention to monetary theory as it is more aligned to the implication of currency volume in the circulation with attendant impact on price level and transactions in an economy (Choi & Rocheteau, 2021; Mankiw, 2020). The theory is otherwise referred to as quantity theory of money and it extends to relate money in circulation (M) with price level (P) and volume of transaction (Y). This connection can further be formulated as follows:

$$MV = PY + \epsilon_t \quad (1)$$

Where M is volume of money, V is velocity, P is price level and Y is transaction volume. The implication of this model is that the extent of currency in circulation can influence the growth rate of the economy through

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the volume of transactions. The equation can be further respecified which by implication will have a reflection of Saint Luis equation (Belliveau, 2011; Timilehin et al., 2019).

$$\Delta Y = \alpha + \Delta M + \Delta(R - E) + \Delta H + \epsilon_t \quad (2)$$

In this equation, ΔY reflects change in economy's total income/output, ΔM indicate change in monetary aggregate and $\Delta(R - E)$ account for the variation in the level of income generation and government expenditure. By implication, it gives a reflection on whether the economy is in surplus or deficit. The ΔH accounts for other changes in the economy. What this suggest is that the level of output or income of an economy can be influenced by volume of money in circulation with the rate of spending and extent of income generation by both private individuals and government. If we take natural logarithm of the variables of concern in the above equation, then we will have the following:

$$logY = \alpha + logM + logF + \epsilon_t \quad (3)$$

The specification in Equation 3 is in logarithm form which implies that the variables are in percentage. In this above, M and F respectively capture the monetary policy route and fiscal policy route to output growth of the economy. This connection will be aligned with relevant variables in the specification of our model under the next section.

3.1. Model Specification

A model is simply an abstraction of reality. The ARDL methodology will be the estimation technique that this study will employ. The choice of this method is due to its simplicity and the ability to capture both short and long run period of any analysis. The model is thus specified below:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \beta_1 dcr_{t-1} + \beta_2 exr_{t-1} + \sum_{j=i}^{p-1} \delta_i \Delta y_{t-i} + \sum_{j=i}^{s-1} \gamma_{1,i} \Delta dcr_{t-i} + \sum_{j=i}^{r-1} \gamma_{2,j} \Delta exr_{t-i} + \epsilon_t \quad (4)$$

Where y is the variable that measure economic growth which will be proxied by GDP growth rate/production index, dcr measures the returns of digital currency and exr is the real exchange rate for the Nigerian economy. The usage of digital currency returns is to capture our analysis via investment route. It is common to measure the behaviour of investors through possible returns to their investment. In another instance, most of people who are into cryptocurrency are solely doing it for investment purpose. Hence, the nature of return to any digital currency will inform the extent of their involvement with far reaching impact on the concerned economy. Therefore, this analysis will take cognizance of this implication.

In other specification, we will equally use ARDL to estimate the impact of volatility to digital currency on both economic growth and exchange rate. The concerned model for this analysis is presented thus:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \beta_1 vdr_{t-1} + \beta_2 exr_{t-1} + \sum_{j=i}^{p-1} \delta_i \Delta y_{t-i} + \sum_{J=i}^{s-1} \gamma_{1,i} \Delta vdc_{t-i} + \sum_{J=i}^{r-1} \gamma_{2,j} \Delta exr_{t-i} + \epsilon_t \quad (5)$$

All the variables are as defined earlier. However, our consideration in this case is centered on the volatility of the prices of digital currencies. This volatility was extracted by using standard deviation approach.

The ARDL model that is specified above is for both short – and long-run periods. As shown in the equations, the short run impact is given by γ_1 and γ_2 in the stated equations while the long run impact is captured by $\frac{\beta_1}{1-\rho}$ and $\frac{\beta_2}{1-\rho}$ respectively for digital currency return and exchange rate. The Error Correction Model (ECM) term is $1 - \rho$ in this analysis indicates the degree of adjustment after any possible disequilibrium.

This study will also estimate the causality among the variable of choice. To account for this, the following equation shall be estimated:

$$y_t = a_{1,0} + \sum_{i=1}^{k} b_{1i}.y_{t-i} + \sum_{i=k+1}^{k+dmax} b_{2i}.y_{t-i} + \sum_{i=1}^{k} \beta_{1i}.dc_{t-1} + \sum_{i=k+1}^{k+dmax} \beta_{2,i}.dc_{t-1} + \epsilon_{1t} \quad (6)$$

$$dcr_t = a_{1,0} + \sum_{i=1}^{k} b_{1i}.dcr_{t-i} + \sum_{i=k+1}^{k+dmax} b_{2i}.dcr_{t-i} + \sum_{i=1}^{k} \beta_{1i}.y_{t-1} + \sum_{i=k+1}^{k+dmax} \beta_{2,i}.y_{t-1} + \epsilon_{1t} \quad (7)$$

Equations 6 and 7 indicate bidirectional causality between digital currency and economic growth rate of the country. While Equation 6 is specifically for economic growth respect to digital currency, Equation 7 on the other hand has implication for the direction from digital currency to the growth rate.

4. Data and Preliminary Analysis

4.1. Data Description

The descriptive statistics of variables is considered in this section. The variable information on average, median, minimum, maximum, kurtosis, skewness, coefficient of variation and Jacque Bera statistics are presented in Table 1. For the returns of digital currency as shown in panel A, the average returns for Bitcoins,

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Ethereum and Litecoin are all positive, ranging from 0.0028 for Bitcoin to 0.0012 for Litecoin. While they are positively skewed, they are equally leptokurtic, as they have high-hump shape. In other words, they kurtosis values for the returns exceed the threshold of 3. As for the level of dispersion, returns for bitcoins is relatively dispersed while that of Litecoin is the least dispersed given its value of standard deviation of 0.0069 and value of coefficient of variation of 5.8104. The implication therefrom is that Litecoin is moderately stable by prices and returns. However, the Jacque Bera statistics indicate that the returns are normally distributed except for the returns of Bitcoin whose probability value is less than the threshold of 0.05%. As for the frequency of the observation, returns for Bitcoin has 48 observation, Ethereum, 28 observation and Litecoin, 26 observations.

The information in panel B Table 1 contains descriptive information about the volatilities of Bitcoins, Ethereum and Litecoin. The extraction of their volatilities is done through the usual standard deviation approach where the rolling windows of one month is considered for daily prices and thereafter annualized. It was subsequently aggregated and averaged to derive it quarterly data form as used in this study. The average values of volatilities of all the coins considered range between 75 and 85 with maximum of 275.7 for bitcoin and minimum of 12.08 for Litecoin. Information about their level of dispersion indicates that their volatilities are mostly dispersed. The very high level of standard deviation and lower value of coefficient of variations are largely indicative of this submission. Aside bitcoin, the distribution of the observation as suggested by the Jacque-Bera statistics is relatively normal while the frequencies of observation are respectively 48, 28 and 26 for Bitcoin, Ethereum and Litecoin.

Given the focus of this study, consideration is given to Gross Domestic Product (GDP) growth rate of the Nigerian economy alongside exchange rate (both nominal and real). The inclusion of exchange rate is motivated by the fact that digital currency activities are carried out across the globe with wider implication on global variables that is inclusive of exchange rate. The average value of GDP growth rate is 3.06, it is highly dispersed and negatively skewed. By distribution, it is normal and thinly shaped given the kurtosis value of less than the threshold value of 3. While the average nominal exchange rate is ₦259.8 to $1 that of real exchange rate is ₦79.5. They are moderately dispersed given the CoV of 0.1362 and 0.3652 for real and nominal exchange rate. Also, the probability of Jacque-Bera statistics as shown in panel C of Table 1 indicates that the two variables are normally distributed. Their observations are 48 which range from 2010Q4 to 2022 Q3. This frequency is long enough for any possible analysis as in the case of the present studies where all the variables of estimation are not exceeding four.

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Table 1. Descriptive statistics of the variables.

Item	Mean	Median	Max.	Min.	Std. dev.	Skew	Kurt	CoV	J-Bera	Prob	Obs.	Freq.
Digital currency returns												
RBit	0.0028	0.0009	0.0330	-0.0125	0.0081	1.3116	6.0139	2.8849	31.9285	0.0000	48	2010Q4–2022Q3
REther	0.0018	0.0010	0.0201	-0.0123	0.0073	0.6730	3.6116	4.1626	2.5499	0.2794	28	2016Q1–2022Q3
RLit	0.0012	0.0003	0.0187	-0.0091	0.0069	0.7561	3.3105	5.8104	2.5815	0.2751	26	2016Q3–2022Q3
Digital currency volatilities												
VBit	78.586	59.094	275.726	24.642	51.155	1.941	6.804	0.6509	59.0892	0.0000	48	2010Q4–2022Q3
Vet	83.285	82.989	129.688	53.244	19.597	0.671	2.708	0.2353	2.1980	0.3332	28	2016Q1–2022Q3
VLit	84.265	80.355	172.479	12.075	32.827	0.590	4.268	0.3896	3.2523	0.1967	26	2016Q3–2022Q3
Other variables												
GDPR	3.0564	5.6590	16.8579	-14.4551	7.9976	-0.5746	2.4542	2.6167	3.2371	0.1982	48	2010Q4–2022Q3
NX	259.83	304.19	426.30	151.65	94.89	0.2698	1.6147	0.3652	4.4203	0.1097	48	2010Q4–2022Q3
RX	79.549	76.772	105.300	60.793	10.831	0.5793	2.4631	0.1362	3.2612	0.1958	48	2010Q4–2022Q3

Note: RB, REt, RLit are respectively returns on Bitcoins, Ethereum and Litecoin while VB, VEt, VLit volatilities for Bitcoins, Ethereum and Litecoin. GDPR is the GDP growth rate, NX is nominal exchange and RX is the real exchange rate. CoV is the coefficient of variation and it is calculated as the standard deviation over means. Higher value indicates greater dispersion and vice versa.

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4.2. Pre-Estimation Test: Unit Root Test

One of the precondition for using the model for the present study's estimation is that the combined variables must exhibit combination of I(1) and I(0) variables. As shown in the Table 2, this condition is met. While growth rate variable, returns and volatilities of selected coins exhibit stationary at levels, other variables such as nominal and real exchange rate are only stationary after first differencing. This is enough as evidence to proceed with using the specified ARDL model for this study.

Table 2. Unit root test.

Variable	Augmented Dickey Fuller (ADF)		Philip Peron (PP)	
GDP_GR	-3.3509**	I (0)	-15.4629***	I (0)
RetBit	-7.2559***	I (0)	-7.2559***	I (0)
RetEthe	-4.0807***	I (0)	-4.0807***	I (0)
RetLit	-4.1358***	I (0)	-4.1358***	I (0)
VolBit	-4.0007***	I (0)	-3.8618***	I (0)
VolEth	-3.8862***	I (0)	-3.8748***	I (0)
VolLit	-3.742***	I (0)	-3.7241***	I (0)
RX	-5.8163***	I (1)	-5.7473***	I (1)
NX	-2.7415*	I (1)	-7.4433***	I (1)

Note: ***, **, and * indicate 1%, 5% and 10% level of significance respectively.

5. Stylized Facts: Digital Currency (Bitcoins, Ethereum and Litecoin)

Figure 1a presents the trend analysis for Bitcoin's returns and volatility and exchange rate for Nigeria. The connection between returns and volatility of bitcoin as shown in Figure 1a conforms with the fundamentals. When market condition is volatile, returns are expected to be wanning, and waxing when otherwise. This condition is not only evident in the earlier period of 2011 but the trend is equally exhibited in the later period of year 2020 and beyond. Since bitcoin is mostly traded for investment purpose, at a period when the market is stable, returns to it will be large enough to entice the potential investors for any meaningful investment. Similar evidence is found for Ethereum and Litecoin. According to Figures 1b and 1c, in many of the cases where volatilities for either of the two currencies are lows, returns to them are always high. This gives an indication that such feature is common for any digital currency market.

Again, the trend among these variables further evident the salient relationship that is expected to play out among them. In many instances as suggested by various time periods, at any point where volatility is low, exchange rate is found to depreciate (this is mostly visible in periods between 2017 to 2019). Indeed, with higher volatility in digital currency market, local investors hold less bitcoin, thereby giving the local currency the strength to withstand the global pressure. However, this condition is not met in some other instances as indicated in the graph. This can possibly arise when investors rather than holding local currency in lieu of bitcoin, now hold other digital currencies not capture by this study or other similar foreign assets. The ability of local currency to gain strength due to this may be lost when the fund has been diverted to other global variables. The trend for Ethereum and Litecoin in relation to exchange rate trend as shown in Figures 1b and 1c can also be explained on this basis as done for Bitcoin. Indeed, a casual look at the graph show similar features as exhibited by Bitcoin.

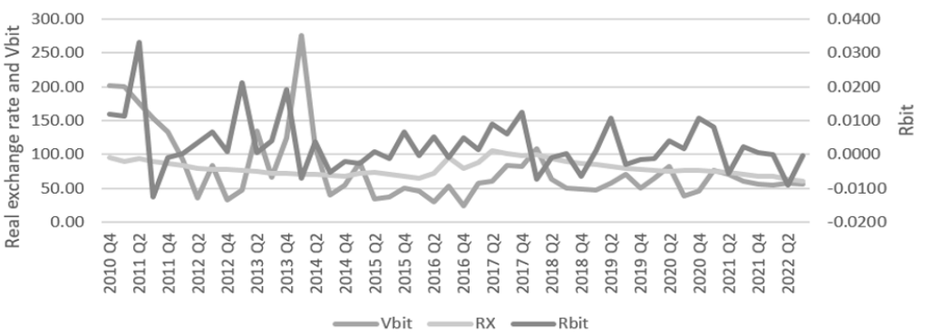


Figure 1a. Co-movement of Bitcoin returns, Bitcoin volatility, and Nigeria real exchange rate.

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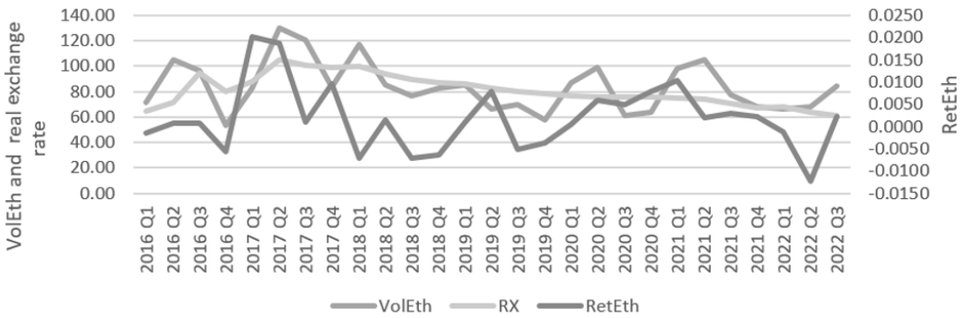


Figure 1b. Co-movement of Ethereum returns, Ethereum volatility, and Nigeria real exchange rate.

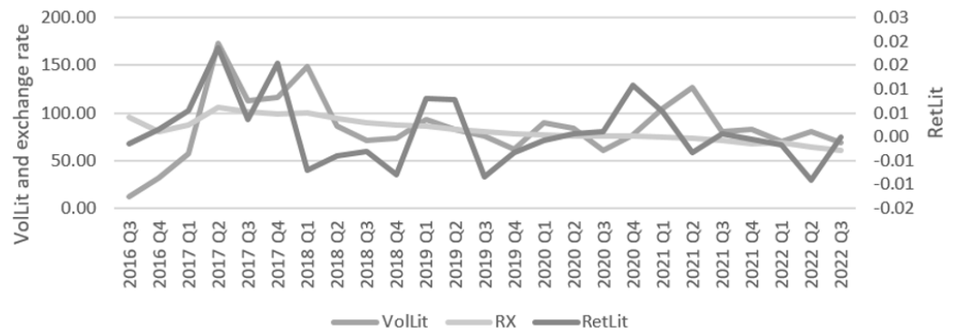


Figure 1c. Co-movement of Litecoin returns, Litecoin volatility and Nigeria real exchange rate.

6. Results

6.1. Digital Currency Returns and Growth

As a way to evaluate the dynamic relationship between digital currency and economic growth in Nigerian economy, an autoregressive model is formulated where returns for each digital currency as considered for this study is modelled alongside exchange rate and economic growth rate. For sensitivity of the analysis, both real and nominal exchange rate are used. Given this methodology, it gives the privileged to account for both short and long-run estimations upon satisfying the necessary condition which our model essentially exhibit. In Table 3, the result indicates that Bitcoin and Litecoin returns are negatively related to Nigerian economic growth rate, though not significant while return for Ethereum exhibit opposite result. On the other hand, real exchange rate appreciation is found to be contributing to economic growth of the country across the entire digital currency markets. This suggests that lower return in digital currency market leads to lower investment by the Nigerian citizens and the resultant effect will improve the currency strength of the country. By implication, exchange rate serves as the pass-through for the impact of digital currency returns on the country's economy. In the alternative analysis where nominal exchange rate is used, the results give supports to the earlier findings in all terms.

In the second model, the long run impact is estimated. As a precondition for analyzing long run impact, bond test is highly necessary. The F-statistic therefrom must be greater than the upper bound where it exhibits I (1) status, otherwise only short run model will be analyzed. As for this study, this condition is met for all the estimation in this model. According to the long run results, the short run implication for the estimation when real exchange rate is considered is equally upheld. This gives an indication that digital currency trading by the Nigerian citizens has been largely embraced and even gone beyond the expectation of the government. The alternative model also serves as a good confirmatory of the base-line analysis. In all, the entire result indicates that when returns to digital currency is very high, the country's growth may fall as more fund will be invested into this market where the attendant effect will become pronounced on the exchange rate by losing its strength against international currency especially dollar.

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Table 3. Digital currency's return and economic growth.

Variable	Bit coin		Ether coin		Lit coin	
Dependent variable: GDP growth rate						
Model I	Short run model					
Variable	Coef.	P-value	Coef.	P-value	Coef.	P-value
Return	-18.5122	0.8320	17.4544	0.8814	-7.7928	0.9498
RX rate	1.2936	0.0024	2.3779	0.0000	2.4447	0.0000
Model II						
Return	-6.2176	0.9421	45.9844	0.7917	-8.0672	0.9220
NX rate	1.0490	0.0015	1.0204	0.0003	-104.0786	0.0001
Model I	Long run model					
Return	-9.9725	0.8315	5.1587	0.8815	-2.3413	0.9498
RX rate	0.6967	0.0000	0.7028	0.0000	0.7345	0.0000
Variable	F-stats	T-stats	F-stats	T-stats	F-stats	T-stats
Bond test	3.7835*	-3.3621**	44.9999***	-11.6093***	37.4861***	-10.4590***
Model II						
Return	-3.2380	0.9421	23.2479	0.7916	-39.2468	0.1801
NX rate	0.5463	0.0000	0.5159	0.0001	0.6359	0.0000
Variable	F-stats	T-stats	F-stats	T-stats	F-stats	T-stats
Bond test	4.1585**	-3.5227***	31.4357***	-9.7059***	89.5158***	-16.3715***

Note: *, ** and *** indicate level of significance at 10, 5 and 1 percent respectively. Also, RX is real exchange rate while NX is nominal exchange rate.

6.2. Digital Currency Volatility and Growth

In this sub-section, the main focus is to estimate possible implication of digital currency volatilities on growth rate of Nigerian economy as well as its exchange rate. Indeed, their volatilities are expected to have much implication on the country's economy given the large number of her citizens being involved in the digital currency market. When market condition is volatile, it becomes difficult for investors to accurately predict the direction of market forces. In essence, investment portfolio for the concern market could be downsize with extended effect on the volume of trade, returns and several other associated macro variables. In connection to this, information provided in Table 4 shows the connectivity between volatilities of selected digital coins and Nigerian economic growth rate overtimes alongside the country's exchange rates.

The estimation as contained in the table has two forms: the short-run and long-run estimations. In the short run, the impact of digital currency volatilities is found to be negative, albeit significant for Ethereum [-0.1443, (0.0490)] on the economy's growth rate while the impact on the real exchange rate is further found to be positive and significant across the entire markets. The implication therefrom is that when digital market is volatile, most Nigerian investors engage in portfolio diversification into the local assets and as such raising the growth rate of the local economy and its extended impact is pronounced as exchange rate further appreciate. The outcome from the sensitivity analysis where nominal exchange rate is used aligned with the base-line estimation and in a way gives some soundness to the study's submission.

In the second model, long-run evaluation of the stated model is carried out. This analysis becomes necessary after meeting up with the required conditions as suggested by the bond tests at various level of significance. Essentially, to estimate long run model, the F-statistics from the bond test is expected to be greater than the upper bound in at least 10% level otherwise only short run model will be estimated as this would have suggested no long run cointegration. Since this condition is met, the long run analysis is further estimated and the result is shown in Table 4. According to this result, the condition exhibited between digital currency volatilities and Nigerian economic growth in the short run is further established in the long run. This goes to say that digital currency market volatilities will have lasting (albeit negative and significant) impact on the Nigerian economy possibly through its exchange rate route. The alternative analysis when using nominal exchange rate gives support to the initial findings when real exchange rate is considered.

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Table 4. Digital Currency's volatility and economic growth.

Variable	Bit coin		Ether coin		Lit coin	
Dependent variable: GDP growth rate						
Model I A	Short run model					
Variable	Coef.	P-value	Coef.	P-value	Coef.	P-value
Volatility	-0.0133	0.3049	-0.1443	0.0490	-0.0369	0.3897
RX rate	1.4357	0.0014	4.1802	0.0063	2.1151	0.0243
Model I B						
Volatility	-0.7877	0.4590	-0.1461	0.0161	-0.0347	0.2355
NX rate	1.0046	0.0023	1.8429	0.0912	-21.3457	0.0797
Model I A	Long run model					
Volatility	-0.0075	0.3470	-0.0696	0.0431	-0.0194	0.3916
RX rate	0.8116	0.0000	2.0167	0.0042	1.1149	0.0235
Variable	F-stats	T-stats	F-stats	T-stats	F-stats	T-stats
Bond test	4.2315**	-3.2249**	37.9189***	-10.6475***	32.0197***	-9.7516***
Model II B						
Volatility	-0.4266	0.4855	-0.0284	0.4325	-0.0103	0.2432
NX rate	0.5441	0.0000	0.9817	0.0714	0.7389	0.0000
Variable	F-stats	T-stats	F-stats	T-stats	F-stats	T-stats
Bond test	4.4040**	-3.3598**	39.1121***	-10.1485***	48.0376***	-11.7252***

Note: ** and *** indicate level of significance at 10 and 5 percent respectively. Also, RX is real exchange rate while NX is nominal exchange rate.

6.3. Causality between Digital Currencies and Growth

In other to further our analysis on the connection between digital currency and the Nigerian economic growth rate, the causal implication among the variables of choice is tested using granger causality test. According to this test, when F-statistics is significant, the causality between the concern variable is upheld, otherwise the null hypothesis of no granger causality is accepted. The main reason for testing the causality is to ascertain the causal effect among the variable of choice. Importantly, when policy makers are acquitted of the knowledge about which variable causes another and of which direction, then the policy stance for such economy can be well specified. This reflects the idea for our analysis in this section.

Accordingly, information in Table 5 contains two panels: panel for causality on returns, and panel for causality on volatility as used in this study. For causality on returns, Litecoin returns granger cause growth rate for the Nigerian economy which gives an implication of unidirectional causality between them. At the same time, Nigerian economic growth rate granger causes Bitcoin returns (which gives to one-way causal effect). No causality is found for Ethereum coin. Also, for nominal exchange rate, Bitcoin returns granger cause nominal exchange rate [2.5321(0.0958)] and nominal exchange rate granger causes returns for Ethereum coin [5.1089(0.0095)]. Again, the study finds bidirectional causality between Ethereum coin and real exchange rate while the same exchange rate granger causes Litecoin returns. This outcome has implication on the digital market activities particularly in relation to the Nigerian economy. Essentially, when returns causes growth rate, it suggests that a larger number of the citizen uphold the assets for investment purposes. Thus, higher returns therefrom are used to financed local economic, perhaps through spending on local goods and investment channel.

In the second panel, causality between volatilities of digital currency is tested against other variables as used in the model. The study finds growth to granger causes volatility for Bitcoin and Litecoin in one-way direction while bidirectional causality is found between Ethereum and growth rate. For the same Bitcoin, nominal exchange rate is found to granger causes returns in both directions while one-way directional causality is found for other two coins. Also, volatilities of Bitcoin and Litecoin granger cause real exchange rate, albeit in other direction for Litecoin while causality between Ethereum and real exchange rate is running from nominal exchange. This outcome has important implication. The causal effect from volatility to growth implies that volatile digital market condition will result in investment portfolio switching which might lead to improved economic condition. On the other hand, improved economic condition suggest higher individual income that can possibly contribute to higher asset diversification like holding more digital currency instead

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of stock, bond and others. However, sudden demand for digital currencies such as Bitcoin, Ethereum and Litecoin could have wider implication on their volatilities given the large number on Nigerians that are into this activity.

Table 5. Causality: Digital currency, exchange rate and growth.

Null hypothesis	Obs.	Lag	Bit coin [i]	Ether coin [ii]	Lit coin [iii]
			Returns		
Panel A			**F-stats(p-v)**	**F-stats(p-v)**	**F-stats(p-v)**
Returns not g-cause growth	41	7 [i]	0.4664(0.8498)	1.1538(0.3356)	4.7315(0.0402)
	25	2 [ii]			
Growth not g-cause returns	20	5 [iii]	2.1635(0.0719)	0.4722(0.6304)	0.6315(0.7047)
Decision			One way (←)	Zero way	One way (→)
Returns not g-cause NX	35	13 [i]	2.5321(0.0958)	0.4012(0.8046)	0.2391(0.7898)
	24	3 [ii]			
NX not g-cause returns	25	2 [iii]	0.8356(0.6288)	5.1089(0.0095)	0.3256(0.7262)
Decision			One way (→)	One way (←)	Zero way
Returns not g-cause RX	43	5 [i]	0.3106(0.9029)	5.4343(0.0074)	0.6115(0.6945)
	23	4 [ii]			
RX not g-cause returns	20	5 [iii]	0.3713(0.8645)	3.7867(0.0274)	3.4085(0.0528)
Decision			Zero way	Two-way (↔)	One way (←)
		Volatility			
Panel B			F-stats(p-v)	F-stats(p-v)	F-stats(p-v)
Volatility not g-cause growth	33	15 [i]	0.8103(0.6810)	5.4405(0.0288)	0.1178(0.9482)
	26	1 [ii]			
Growth not g-cause volatility	22	3 [iii]	14.9439(0.0644)	2.9774(0.0978)	4.4918(0.0193)
Decision			One way (←)	Two-way (↔)	One way (←)
Volatility granger cause NX	38	10 [i]	3.1250(0.0188)	3.1712(0.0473)	1.0291(0.5419)
	23	4 [ii]			
NX granger cause volatility	18	7 [iii]	2.1227(0.0826)	2.2401(0.1169)	14.7447(0.0247)
Decision			Two-way (↔)	One way (→)	One way (←)
Volatility granger cause RX	38	10 [i]	3.0897(0.0197)	1.6852(0.2091)	12.1990(0.0004)
	23	4 [ii]			
RX granger cause volatility	23	2 [iii]	1.0157(0.4695)	2.9590(0.0577)	3.5129(0.0515)
Decision			One way (→)	One way (←)	Two-way (↔)

Note: The null hypothesis is that 'there is no granger causality' and which holds when f-stats is not significance, otherwise we reject it and accept the alternative hypothesis.

7. Conclusion and Recommendation

Having emphasized the necessity of the present study, the main focus was rather place to investigate the implication of dynamic connection between digital currency and Nigerian economic growth rate. More emphasis is on returns, volatility and causality among the variables. Essentially, three digital currencies are considered and they are: Bitcoin, Ethereum and Litecoin. As a way to have a robust estimation, we model our analysis using ARDL model and granger causality test. This model is rather useful to have both short and long run estimations which in a way allow to verify whether the causal variable has lasting effect on the dependent variables. Importantly the study's outcome conforms with the fundamentals. The trend analysis suggest that the country's exchange rate move in line with digital currency activities while at the same time signifies some implication on the growth rate of the Nigerian economy. While lower returns for Bitcoin and Litecoin increase growth rate, the return for Ethereum rather move in the same direction as the growth rate. This indeed suggest that most Nigerians into digital currency activities often engage in portfolio diversification among available coins. The study further found that low volatility in the market will raise (significantly especially for Ethereum) growth rate of the economy while causal implication run from returns and volatilities among these coins to economic growth and exchange rates. Indeed, the findings from the study have important policy implication for the Nigerian economy.

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