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Crypto currency and economic growth in Nigeria

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Abstract: This study investigates the link between crypto currencies and economic growth from 2012Q1 to 2019Q4. GDP per capita measures economic growth. Bitcoin transactions volume, private sector credit and foreign direct investment measured currency circulation using Engle-Granger residual co-integration, fully modified OLS, dynamic OLS and conical co-integration regression. Results unveil long-term relationship between crypto currencies and economic growth. The findings indicate a negative long-run association between LNBVT and GDP. The Central Bank of Nigeria and government should improve the legal system to regulate crypto currencies transactions. This research suggests implementation of effective laws on crypto currencies transactions to limit crypto currencies' negativities in the global economy. This is possible if the crypto currencies' developers create geographically delimited or encrypted protocols. This study recommends that all economic actors should be open-minded towards technological innovations. The suggested policies would improve crypto currency acceptance in the economies globally. The authorities should regulate crypto currencies' usage and security from illegal activities.

Keywords: crypto currency; economic growth; fully modified OLS; FMOLS; dynamic OLS; DOLS; conical co-integration regression; CCR; Nigeria.

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1 Introduction

The number of poor people worldwide is increasingly high and it is clear that the benefits of economic growth are unevenly distributed across regions and countries (World Bank, 2018). Additionally, incidents of economic chaos like wars, poor governance and governmental collapse are plaguing development in the regions (Prahalad and Hammond,

2002). Moreover, persistent poverty motivated by economic factors such as limited access to finance, financial services and high inflation rates (Aisen and Veiga, 2006; Beck and Demirguc-Kunt, 2006). Furthermore, Barham et al. (1995), Bohari et al. (2022) and Olken (2006) argued that a low level of trust and corrupt government institutions hinder economic growth. Crypto currencies seem to provide substantial benefits which increase social trust and access to financial services (Nakamoto, 2008). Crypto currencies are a medium of exchange which supports the growth process in emerging countries through financial inclusion. The crypto currencies provide better traceability of funds which leads to poverty reduction (Ammous, 2015).

The notion of a digital currency is growing in every economy worldwide. A digital currency is currency which is stored and transferred electronically. It is otherwise known as electronic currency that could be converted into cash, for instance making an automated teller machine (ATM) cash withdrawal (Tiku and Singh, 2023). The digital currency consists of virtual and crypto currencies alongside the traditional currency deposited in banks (Agbo and Nwadialor, 2020). Digital currencies are exchanged and transferred using technologies which has rise to online banking and eliminates the cash transactions dependency or need to personally visit a bank (Kelly, 2015). One of the popular digital currencies is crypto currency. A crypto currency value is created by the users who accept it as an exchange medium. The crypto currencies depend on mathematics and encryption contrary to the traditional currencies which depend on the central banks. Trust and adoption give the currency value alongside the users' anticipation to use the currency in future. The crypto currencies' users place trust in the basic structure rather than a central authority (Vigna and Michael, 2015).

Since most crypto currencies provide both payment infrastructure and currency, the crypto currency market creates new possibilities in different regions. Crypto currencies are digital assets serving as a medium of exchange using cryptographic platforms to secure transactions. The new financial technology especially the Bit coin protocol is attractive to the business sector and motivates research within this area. This new technology is considered the future of money that will change the current payment systems (Chuaban et al., 2022; Tapscott and Tapscott, 2016). The Bitcoin is a peer-to-peer electronic cash system which was published by alias Satoshi Nakamoto in 2008. This paper describes the crypto currency as a means to solve the problem of double spending and eliminates the need of a central authority like a central bank, money supply and physical security. The rules of the system are encoded and encrypted within the system (Nakamoto, 2008). The real identity of the system's creator remains anonymous but the bitcoin protocol is gaining global recognition creating a market for crypto currencies. The bitcoin is the first crypto currency ever implemented. By 2017, there exist over 800 crypto currencies with a total market capitalisation of about 309BSEK. Presently, bitcoin occupies 61.4% of the crypto currency market followed by ethereum, ripple and litecoin (CoinMarketCap, 2017).

A crypto currency is a type of digital currency that uses cryptography for security enforcement against counterfeit. Crypto currencies differ from virtual currencies in that the currencies are designed as potential substitutes for the traditional currencies. Contrary to other currencies like the virtual, digital and traditional currencies, crypto currencies are decentralised. This implies that no centralised authority controls the money supply. Crypto currencies eliminate the functions of central banks from the currency markets are structured (Agbo and Nwadialor, 2020). Crypto currency is a digital token produced by cryptographic algorithms and transported across cyberspace through protocols like the

peer-to-peer network (Bryans, 2014). Crypto currency value is gotten from the demand and supply of the tokens. The crypto currency resides in the decentralisation of the financial system.

Bitcoin is a peer-to-peer communication protocol that enables payment systems to use of virtual currency (Böhme et al., 2015). Bitcoin is a form of digital currency created through blockchain technology based on the Nakamoto white paper ideas, which pioneered the blockchain innovation. The introduction of bitcoin launched hundreds of other virtual currencies which are collectively called altcoins. The concept of crypto currencies was initially suggested in 1998. Presently, the bitcoin has become the first practical proof of the theory (Kelly, 2015). The bitcoin is used to explain the functioning of an electronic currency. The usage of bitcoin is growing rapidly. In 2016, bitcoin had 6.56 million users and 11.05 million in 2017 which is more than 1,500% increase (Mezikana, 2019; Weber, 2018). This currency is extremely volatile despite its rapid acceptance and performance in the market due to its value fluctuation in thousands of dollars daily. For instance, one bitcoin sold at about $575 in 2016, $11,000 in 2017, $3,900 in 2018, $10,800 in 2019 and $61,000 in 2020.

The bitcoin is principally used payment transactions. The bitcoins transaction cost is very small which make it easier and affordable to circulate sums of money with high speeds worldwide. Bitcoin transactions are executed almost instantaneously all the time. Nonetheless, the bitcoin is still complementary and not a traditional currency substitute. Bitcoins are a viable solution which eases the entry and exit of a currency that rapidly gain value. The bitcoin usage is mainly speculative motivated than just a means of payment. This has created volatility much higher than similar derivatives like currency exchange rates (Tiku and Singh, 2023). The volatility creates uncertainty about bitcoin value which makes it a risky investment. It is even riskier as a substitute for the traditional currency. DeVries (2016) states that the number of bitcoins that are to be generated is finite which avoid over abundance and ensure its reality. Kelly (2015) indicates that bitcoin value exists because the users have trust and accept it for transactions' payment everywhere globally. With the users' faith in bitcoin, anything could be the valued object. Contrarily, Krugman (2013) states that bitcoin is unreliable to store value. Krugman (2013) discredits the validity of bitcoin as money but conceded that bitcoin is a successful medium of exchange.

Contrary to gold, the bitcoin has no intrinsic value because the bitcoin is not used to make physical objects like jewellery that have value (DeVries, 2016). This contradicts the technology on which the current legal and financial structures are established. Existing financial institutions function on older forms of currency. According to DeVries (2016), if crypto currencies should be used for transactions' payment, the trading systems would be completely reformed to fit the new competition. Therefore, crypto currencies could be the technology that would disrupt the global financial and economic systems. The bitcoin protocol provides the technical infrastructure, which permits direct online payments and a crypto currency which is a peer-to-peer form of electronic money. The digital coin transactions are being performed using digital signatures to sign and verify transactions with strong ownership control. The problem of double-spending existed until Nakamoto proposed the bitcoin protocol which combines technology and advanced mathematics (Agbo and Nwadialor, 2020). The bitcoin protocol does not need users' identification and allows everyone connected to the internet to participate.

Another type of digital currency is virtual currency. A virtual currency is not issued by any central bank. It depends on the system trust. The virtual money is defined as a digital value account issued by the system's developers, which is used in a particular virtual community. An example includes the computer game world of war craft (WoW) where the virtual currency could be purchased in-game. The virtual currency complements the traditional money as it is used only in specified platforms. The virtual currency functions based on the algorithm which is the foundation of the system and most of the virtual currencies are centralised. This implies that the money supply control is centralised in the virtual world (Krugman, 2013). There has been a proliferation of virtual currencies universally (Mazikana, 2019). For instance, Amazon coins, Facebook Credits and Microsoft Points. According to Frankenfield (2019), a virtual currency is money held within a blockchain network that is unregulated by any centralised banking authority. Hence, the currency experiences remarkable price variations as the only real trading force on consumer sentiment.

Mckenzie (2018) states that a virtual currency is an unregulated digital currency which is issued and controlled by the developers. The currency is accepted and utilised by a specified virtual community population. Harvey (2015) indicated that other virtual currencies are issued by companies and the currencies are not backed by any claims on real assets. The virtual currencies value and distribution are typically controlled by a centralised authority, which is the issuing company that facilitates online transactions. Several regulators are worried about crypto currency decentralised nature. The financial technology community argues about the inevitable widespread crypto currencies use. According to Moore and Stephen (2016), global financial corporations like Citibank are creating their own crypto currency to benefit from the protocol utilisation. Crypto currencies are similar to physical currencies than some virtual currencies since they serve as a medium of exchange for physical assets. The modern world's money supply is digitalised; hence they are viewed to be in crypto currencies format (Harvey, 2015). Crypto currencies show greater potential for socio-economic inclusiveness with enhanced financial security. Recently, the rise of bitcoin caused crypto currencies to be more relevant worldwide (Stancel, 2015).

The challenges of crypto currencies include early illiquidity track record, high volatility and potentially questionable uses (Harvey, 2015). The challenges on the effective use of crypto currencies focus on whether they are digital or virtual currencies and their value determination. Raffelini (2018) posits that there are debates in financial literature on whether or not crypto currencies meet the money criteria. There is equally doubt if crypto currency is stable store of money value or an effective and efficient medium of exchange. Additionally, politicians often focused on the issue that criminality takes advantage of digital currencies to cause harm. This approach creates moral and ethical conflicts than alternative solutions to crypto currency usage. There are two major schools of thought on the future usefulness of crypto currencies especially bitcoins (Bryman, 2015). The libertarian views are optimistic and accept the crypto currency system. The optimists argue that crypto currencies ease funds transfer between parties to a transaction through the public and private keys. The fund transfers processing fees are very minimal. Bitcoin promoters argue that the increase market capitalisation of bitcoin, ethereum and other crypto currencies creates a very large and powerful market which is costly to ban (Bryman, 2015). Currently, about 95% of the money worldwide is digital (SiaPartners, 2015).

However, other authors, economists and scholars reluctantly embrace the use of crypto currency system of financial transactions' payments. The crypto currencies critics claim that crypto currencies are very volatile and are used for money laundry or illegal activities financing. The critics posit that crypto currencies have inherent contradictions which make their widespread usage as money difficult. Block chain is simply considered a big database. Roubini and Krugman (2013) expressed scepticism about crypto currencies and block chain. Whatever the negative features of crypto currency, emerging countries especially in Africa apparently need an alternative means of funds exchange. McKenzie (2018) posits that Africa has the second highest world population of unbanked adults, which is about 350million people, that is 17% of the global population.

Mazikana (2019) describes block chain as a constantly updated and maintained computer ledger. This is a distributed ledger technology that groups transactions into blocks cryptographically together and broadcasts them to the peer-to-peer network nodes. The motive is to establish an irreversible and distributed database of the transactions. This technology aims to create a consensually shared and synchronised database across a network spread using multiple sites, institutions and locations. With block chain, the traditional middleman role which required financial institutions like banks with supervisory authorities is eliminated. The block chain is publicly available for everyone as a public ledger which is updated after each transaction and everyone owns a copy of the ledger. This might imply limited privacy; nonetheless, all the transactions and accounts in the block chain are anonymous from recoding. This is a technically computerised process.

The public ledger is advantageous in that third party or middleman trust no longer exist. Each transaction is a block which is computer controlled and approved. The verifiers are called miners (Dwyer, 2015). After approval, the transaction is included into the block chain. Since every transaction is public, any corruption attempt is flagged by the mathematics (algorithm) behind it and prevents all ledgers consensus. Thus, this basically prevents fraudulent transactions. Therefore, the financial intermediaries' functions are partially replaced by crypto graphical verifications (Swan, 2015). Lee et al. (2018) stated that bitcoin is used to trade electronically just like the conventional currencies are traded digitally. Bitcoin is differentiated from any fiat money or platform-based digital currencies through decentralisation since no group or institution controls the bitcoin network. Bitcoin supply is governed by a procedure and anyone accesses it through the internet. The bitcoin wallets or addresses are easily created online with no charges or regulations. Moreover, the transactions are not localised and the bitcoins are transferred across different countries.

Each bitcoin transaction is broadcasted to the entire network. The transactions are validated through mining nodes or miners who record in the block which are created and broadcast the whole block to other nodes. All transactions are stored in the block chain, which is openly distributed to the miners to verify and have a copy (Lee et al., 2018). Bitcoin transactions are broadcasted within seconds. The miners take about ten minutes to verify a bitcoin transaction. This implies bitcoins transfers across the universe takes just few minutes. There is a fixed limit of bitcoins to be mined. King (2013) stated that bitcoins are mined in diminishing returns each four years with a total of 21 million maximum bitcoins. This feature provides value to bitcoins and avoids excessive inflation (Ivaschenko, 2016). The bitcoin is generally protected from inflation from the different governmental changes and restrictions (Magro, 2016). The price of bitcoins fluctuates

wildly due to several other external factors and quickly refuges against inflation of national currencies.

According to Desjardins (2016), the combination of safe haven option demand and price volatility allows bitcoin to be the best performing currency from 2015 based on the US dollar index. The crypto currency is a strong, currency that is bought and sold expeditiously worldwide. Although fiat currencies are stronger and desirable, the currencies cannot compete with the agilities of crypto currencies. The bitcoin is capable of filling existing gaps in financial technologies and solve the traditional banking problems as a peer-to-peer system. It remedies the problems of unbanked consumers which exist significantly in the population of developing countries (Magro, 2016). Crypto currency is advantageous over traditional currencies because of its ability to make fast peer-to-peer transactions, mainly in international business scenarios.

Bitcoins show some internal weaknesses due to the design which cannot easily be modified. The public blockchain is available to all users and as such, it is subject to attacks from the easy access (Hileman, 2016; King, 2013). The bitcoin network cannot accommodate high load transaction rates. Crypto currency leads to fraudulent transactions due to limited government tracking and its anonymity. Silk Road is an online market found in the dark-net, which permits drug dealers and other customers to illegally trade in drugs using digital currencies (Bearman, 2015). The in-built crypto currencies security flaws and oversights allow hackers to float bitcoins from the exchange. This situation makes to lose value when the users sell bitcoins, with the fear that coins can be stolen. Etherium is another form of crypto currency which is open-source and blockchain-based platform. Its operating system lost about 50 million US dollars to hackers. These hackers generally targeted large crypto currency holders with poor security standards (Price, 2016). The crypto currencies' ability of trading as commodities is a weakness as commodity-based markets disclose great value fluctuation from different events. This value fluctuation ultimately reduces the investors' commodities trust.

The inability to establish a bitcoin price determinant creates uncertainty in the trading arena. This affects users of bitcoin currency with varying value fluctuations. The price volatility generates risk that discourages sellers and buyers to hold crypto currency within a significant period (PwC, 2015). Much crypto currency risk decreases consumer trust and limits legitimacy validation. A bitcoin lost in a bitcoin wallet cannot be recovered, except it is backed by phrase code (Khan, 2014). Hildi (2013) indicated that the bitcoin deflationary feature negatively affects its usage as speculators exploit it to create an economic recession. The value fluctuation which is intrinsic in bitcoins is doubtful to users and investors.

Also, crypto currencies are not yet legally regulated by law which limits users' acceptance. The World Law Library of Congress (2019) which is a crypto currency status and regulatory organ reveals 130 countries and some regional organisations with policies on crypto currencies since crypto currencies is everywhere. Thus, many national and regional authorities are working hard to provide some crypto currencies' regulation. The Law Library of Congress (2019) states that the terminology describing crypto currency varies across jurisdictions, despite crypto currencies similarities based on the encrypted and decentralised block chain technology. Most government are issuing notices on the dangers of investing in crypto currencies. This is done by central banks to educate the citizens on the differences between fiat currencies, which are state guaranteed and unregulated crypto currencies. The governments have expanded laws on money laundering, counterterrorism and organised crimes to involve crypto currency markets.

This requires banks and other financial institutions in markets to respect all the due diligence requirements of the laws.

Nigeria provides the largest market in digital money. In 2017, the Central Bank of Nigeria (CBN) constrained virtual monetary standards. The CBN expressed that crypto currencies' exchanges are untraceable and mysterious to a greater extent. Therefore, the digital currencies are vulnerable to maltreatment by culprits, especially illegal tax avoidance and psychological warfare financing. The Nigerian government and CBN recognise their limitations to implement digital currency laws. The CBN conceded in 2018 that it cannot regulate bitcoin usage and direct block chain. Similarly, the government asserts that internet usage uncontrollable and limited in Nigeria due to poor infrastructure. The Nigerian government and CBN persuade and caution residents that digital currencies are illicit and anyone trading in digital currency is taking a personal risk. As such, the state dispenses cryptographic money clients in the market (Pandya et al., 2019).

The potential risks of virtual currencies which interest the central banks include price stability, financial stability, payment system stability, limited regulation and reputation. Virtual currencies make the price stability process difficult as it distorts the central banks' money supply control via open market operations. The reduced money supply control equally distorts the central banks' ability to intervene in foreign exchange rate markets which affects financial stability. Additionally, virtual currency speculation occurs due to cyber-attacks because no lender of last resort for these currencies exists (Mckenzie, 2018). Hence, this study ascertains the long run relationship between crypto currency and economic growth in the Nigeria from 2012Q1 to 2019Q4. The study would be useful to decision and policy makers like the government and other stakeholders. This study is arranged as thus: section one gives the introduction, section two provides theoretical and empirical literature, section three presents data and methodology, section four focuses on the results and section five diffuses the conclusion and implications.

2 Literature review

2.1 Theoretical framework

Theories provide logical statements to justify different phenomena. The theories analytically give details on relationships between phenomena. Therefore, studies need suitable theories for elucidation (Kombo and Tromp, 2009; Smyth, 2004). Theories guide research, decide the relevant variables along with the statistical relations in a study (Trochim, 2006). This study is based on the following theories:

2.1.1 Misses regression theorem

This regression theorem posits that all money should eventually derive its purchasing power from a commodity historical tie that is valued in a state of barter. Chokun (2014) indicated that the value of money theory traces the objective exchange value of money to a point where the value of money does not longer exists except the commodity value. As such, going further backward one eventually get to a point where components in the objective exchange value of money emanating from valuations from the function of money as a medium of exchange are not longer seen. The value of money becomes the

value of an object which is useful in ways other than money. This circularity problem is resolved through the regression theorem. The value of money results from the marginal utility of goods for which money is exchanged or money expected purchasing power. Furthermore, the expected future purchasing power is based on the current and previous purchasing powers. The regression theorem work when a medium of exchange has the required attributes for a medium of exchange which are price and market acceptance. The bitcoin violates the regression theorem (Agbo and Nwadialor, 2020).

2.1.2 Keynesian theory

This theory was propounded by John Maynard Keynes. The theory is also called demand-side theory which focuses on short run economic variations. Economic growth is either approached from the demand, supply or the aggregate demand and supply sides. The Keynesian theory revealed that the factor that influences economic growth most is spending. The theory relates the growth indicator to income and expenditure. Keynes proposed increase in government expenditure and low taxes to stimulate consumption and investment as a way to pull a country out from global depression. Measuring economic growth from the Keynesian theory, the government uses the gross domestic product (GDP) as a reliable indicator.

2.1.3 Solow's growth model

The neo classical growth model was popularised by Robert Solow in 1960s. The theory is famously called Solow growth model or exogenous growth model. The theory stipulates the possibility of having a permanent GDP per capita growth. In the classical growth model, the population is endogenous while in the neo-classical growth model population is exogenous. The Solow's growth model was initiated in 1950s to response to Harord-Domar model which always had long run economic problems in short-term variables like savings. The Solow's model states that economic growth analysis works with long run tools like land. The model is more open for substitution. Additionally, Solow's growth theory indicates that production factors have diminishing returns; one additional factor to a fixed amount of other factors increases the output. However, as the quantity of the factor increases the output becomes smaller. With the diminishing return on investment, Solow posited that the long-run growth is acceptable with technological progress.

2.1.4 Byzantine generals problem (BGP)

This is the difficulty faced to enforce trust in distributed systems where components need to communicate information between one another which might done inaccurately. In establishing decentralised ledgers, a couple of obstacles are encountered with the most prominent being trust. The Byzantine generals' problem was initially revealed by (Marshall et al., 1982). The need for trustworthy computer systems to overcome malfunctioning components which give incompatible information to various parts of the systems are abstractly expressed as a group of Byzantine army generals with troops camping in an enemy environment. The generals need a common battle plan while communication within them is ensured by an agent. This network assumes that one or more generals could be traitors to derail others which makes the possibility of the

generals to agree becomes uncertain (Antonopoulos, 2014). The challenge here is to find an algorithm to ensure the use of oral message only. The problem is settled only when over two-thirds of the generals are loyal. Nonetheless, with non-changeable written messages, the traitors´ ability to propagate the problem is solved for any number of generals. As the number of parties in the system increases, the number of communication channels equally increases absolutely.

2.2 Empirical review

Bouoiyour and Selmi (2016) examined daily bitcoin prices applying an optimal-GARCH model. The findings show that volatility has decreasing trend in the pre-and post-2015 data after significant asymmetries in the bitcoin market and the prices vary more negatively than positive shocks. Dyhrberg (2016) examines the hedging of bitcoin in the Financial Times Stock Exchange Market using the Financial Times Stock Exchange Index and against the American dollar in the short-term. The findings show that bitcoins are usable for hedging against stocks. Mothokoa (2017) conducted an analytical, explorative and comparative study employing desktop-research methods with crypto currency. Comparative methods were applied to contrast the legal and regulatory frameworks of Canada, the USA and the EU using the legal position of crypto currencies in South Africa. The results revealed that crypto currencies are convertible decentralised virtual currencies which are cryptographic algorithm based.

Agbo and Nwadialor (2020) explored the global prospects and threats of crypto currencies particularly in Africa. The study specifically examines the bitcoin variations. The study revealed that the private sector is enthusiastically use crypto currency in many countries, but the governments are apprehensive, reserved and not crypto currency receptive. The results show that with a simple endogenous process, countries can ensure the coexistence of fiat and crypto currencies. This allows countries to reap the economic benefits of the centralised and decentralised currency systems. Katsiampa (2017) investigated the bitcoin volatility through GARCH models comparison. The results indicated that the AR-CGARCH model provides the most optimal fit. The study indicated a highly speculative bitcoin market.

El Bahrawy and Alessandretti (2017) investigated the behaviour of 1,469 crypto currencies market from April 2013 to May 2017. The findings indicated that crypto currencies continuously appear and disappear with an exponentially increasing market capitalisation and several stable market statistical properties over some years. Chiu and Koeppl (2019) examined the incentives to stop and continue with secret mining. The findings showed that the incentives are never optimal to stop buyers from double-spending attacks with successful first number of steps. Agu (2020) examined crypto currency regulation in some African countries focusing on the positive economic impacts in Africa. The results reveal that the crypto currency is highly criticised by governments and authorities stating that crypto currency leads to money laundering and financial crime. Also some critics posit that crypto currency creates financial instability. However, the findings showed that the positive influences of crypto currency outweigh the negative effects in the economies.

Holtmeier and Sandner (2019) examined the impact of crypto currencies on individuals and businesses in developing nations to show decision makers the possibilities of using crypto currencies to reduce economic barriers. Crypto currencies

timidly promote economic growth of developing countries. The study showed that crypto currencies considerably impact on developing countries' economies via financial inclusion. Regulations remain the key to future development, price stability and crypto currencies' adoption. Scott (2016) investigated how crypto currency and block chain technology affect the building of social and solidarity finance. The study indicated that decreasing the transaction fees and time, cross-border payments increase which benefits remittance payments, peer-to-peer transactions and international trade. Gartz and Linderbrandt (2017) examined if crypto currencies can replace the Swedish Krona and the implications on the Swedish society. The study revealed that crypto currencies cannot play the functions of the traditional currency. The results concluded that a transition to crypto currency in Sweden is not favourable. Crypto currencies should continuously grow in new market while coexisting with traditional currencies and payment systems. Oktavia and Utomo (2019) examined the influence of crypto currency on economic growth of five Asian countries from 2011-2016 using panel data regression to correlate bitcoin (BTC) with GDP. Three control variables capital (K), labour (L), and Technology (A) were used to ensure unbiased results. The results showed that BTC and technology significantly affects GDP negatively. Labour and capital significantly affects GDP positively. Govdeli (2022) examined the relationship between domestic savings, capital investments and economic growth in Caucasian and Central Asian Countries from 1993-2017 using vector error correction model and granger causality. The results show causality flow between savings and economic growth.

Other studies conducted on the dynamics and indeterminacy of crypto currency equilibrium prices include (Auer, 2019; Choi and Rocheteau, 2019; Eyal and Sirer, 2018; Fernández-Villaverde and Sanches, 2016; Pagnotta, 2018; Saleh, 2018; Schilling and Uhlig, 2018). Many studies have examined the link between crypto currency and economic growth empirically. Literature reveal that limited studies on the connection between crypto currency and economic growth use econometric analysis with bitcoin volume of transactions (BVT), domestic credit to the private sector (DCPS) proxy for financial development and foreign direct investment (FDI) as parameters. Thus, this study examines the relationship between crypto currency and economic growth in Nigeria from 2012Q1 to 2019Q4.

3 Data and methodology

This research utilises the ex post facto research method which is focused on past occurrences of events. The quarterly secondary time series data is obtained from the coin-dance, world development indicators (WDI) and world governance indicators (WGI) from 2012Q1 to 2019Q4, based on available data. Descriptive statistics, correlation analysis which verifies multi-collinearity, unit root test employing Augmented Dickey Fuller (ADF) and Phillips and Peron (1988) tests, autoregressive distributed lag (ARDL) and the bound co-integration test. The results are robust with residual co-integration test and finalised with error correction mechanism (ECM) test. GDP is the explained variable while the explanatory variables are BVT, DCPS, and FDI. The research control variables include rule of law (ROL) and regulatory quality (REQ).

3.1 Model specification

The Engle-Granger two-way residual fixed technique is utilised to link crypto currency and economic growth in Nigeria (Engle and Granger, 1987; Kalu et al., 2015). The residual technique is usable when the variables are either differenced order one or mutually differenced (Engle and Granger, 1987). GDP is measured by the total output in the economy, while crypto currency is measured by the BVT, DCPS, and FDI. The unit root test assists the model selection.

The Engle-Granger analysis technique proceeds as follows: Firstly, the variables unit root test is conducted to determine the integration order. The unit root checks reveal whether or not the time series information possesses average reverting properties. If time series data is all order 1(1) integrated, then the co-integration technique becomes favourable for a long-term relationship evaluation. When the variables are all order zero I(0) integrated, the multiple regression technique favours the estimation and when mutually integrated I(0) and I(1), implies the ARDL model is analytically qualified. The ADF and Phillips and Peron (1988) are used for the unit root test as:

$$\Delta Y_t = \alpha_0 + \beta_t + \alpha_1 Y_{t-1} + \sum \lambda_1 \Delta Y_{t-1} \ldots \lambda_n \Delta Y_{t-n} + \varepsilon_t \tag{1}$$

Y_t indicates a unit root is the null hypothesis such that $\alpha_1 = 1$. Conversely, the alternative hypothesis of the series not exhibiting a unit root, is such that $\alpha_1 < 1$. The ADF and Philip-Peron (PP) tests preference is based on their procedure automatic corrections which allow residuals auto-correlation (Brooks, 2008). When the estimated α_1 coefficient absolute value is less than the ADF and PP critical values at 5% significant level, the null hypothesis that Y_t possesses a unit root is rejected. When the computed α_1 coefficient absolute value exceeds the critical value at 5% level, the null hypothesis that Y_t indicates a unit root is accepted. If the variables integration order is one I(1), the long-run estimation is conducted using regressions on the series datasets according to the classical linear regression model (CLRM) and regression residuals. The formulated CLRM equation is thus:

$$\text{GDP} = \beta_0 + \beta_1 \text{BVT} + \beta_2 \text{DCPS} + \beta_3 \text{FDI} + \beta_4 \text{ROL} + \beta_5 \text{REQ} + \varepsilon_t \tag{2}$$

Here, GDP is gross domestic product, β_0 is the intercept term, DCPS is the domestic credit provided to the private sector, FDI is the foreign direct investment, ROL is the ROL, REQ is the regulatory quality and ε_t is the stochastic term. If the GDP, BVT, DCPS and FDI should co-integrate, the estimated residual from equation (2) has to be stationary, implies [$\varepsilon_t \sim 1(0)$]. The residual-based unit root tests of ADF and PP verifies if the equation (2) residuals are stationary. When the residuals stationarity is unavailable, implies co-integration does not exist and if stationarity is available, implies the series co-integration exists. To discard the null hypothesis of a unit root indicates that co-integration is available (Engle and Granger, 1987). Thus, residual-based estimation is as follows:

$$\Delta\varepsilon_t = \alpha_1 \varepsilon_{t-1} + \mu_t \tag{3}$$

Here, $\Delta\varepsilon_t$ indicates the first difference residual estimation, ε_{t-1} indicates the residuals lags, α_1 is the interest variables coefficient which is the gradient, μ_t is the error term.

The ECM estimation is conducted with the ordinary least square (OLS). This ECM is estimated assuming that two or more time series show equilibrium alliance which specifies the short and long-terms properties. It jointly models the short and long-runs variables relationships. The Granger causality method reveals that for any I(1) variables, the associations is equalised by the error correction and co-integration of the series. This implies that, if variables such as GDP, BVT, DCPS and FDI co-integrate, the ECM would join the variables together. The differentiated ECM model is approximated as follows:

$$\Delta \text{GDP} = \alpha_0 + \alpha_1 \Delta \text{BVT} + \alpha_2 \Delta \text{DCPS} + \alpha_3 \Delta \text{FDI} + \alpha_4 \Delta \text{ROL} + \alpha_5 \Delta \text{REQ} + \alpha_0 \mu_{t-1} \quad (4)$$

where Δ is the equation's difference operator, α_1 to α_4 stand for the estimated coefficients, α_5 denotes a year lagged value of the random term coefficient from equation (2). The α_1 to α_4 estimate the short-run regressors effect on the regressand and α_5 calculates the error correction term (ECT) coefficient which determines the GDP adjustment speed to the equilibrium point due to shocks from the regressors. In econometrics, the α_5 coefficient should be negative and statistically significant for the series to have long-run equilibrium convergence. A negative and statistically significant α_5 coefficient signifies regression co-integration (Engle and Granger, 1987). Moreover, the α_5 size defines the level of the adjustment speed to equilibrium position. Hence, a small α_5 coefficient roves towards –1 indicates a high adjustment speed, whereas larger values rove towards zero (0), indicate low adjustment speed. However, the positive values of the ECT illustrate a divergence series from the long-run equilibrium point. The theoretical variables justification is thus:

GDP per capita income: this is the annual percentage GDP per capita growth rate on regular local currency and jointly estimated on constant 2010 US dollars. It is computed by dividing GDP by half year population (World Bank, 2018). At purchaser's prices, GDP per capita is the total gross value added by all producers in the economy including product taxes less subsidies outside the products values. Additionally, GDP per capita measures individual citizens' income in the economy. Studies that utilised GDP per capita involve (Chukwunulu, 2019). Bitcoin volume of transaction (BVT) is the quantity of bitcoins traded in the digital market. Domestic credit to private sector (DCPS) is the financial resources given to the private sector by financial institutions like loans, non-equity securities purchases, trade credits and other accounts receivable that are repayable. FDI: this is the net investment inflows to obtain a sustainable management interest in any entity in an economy. It consists of equity capital, earnings reinvestment, long and short-term capital flows in the balance of payments. These are net investment inflows in the economy from foreign investors divided by GDP (World Bank, 2018). ROL illustrates the perceptions of agents confidently abiding to the societal rules, especially contract enforcement, property rights, the police and the court rules against the likelihood of crime and violence. It ranges between –2.5 and 2.5 estimated values. REQ refers to perceptions of government's ability to adopt and implement regulations which encourage private sector development. The estimates country's score of standard normal distribution units range between –2.5 to 2.5.

4 Results

4.1 Descriptive statistics

Table 1 gives the measures of central tendency, spread and variations values with the variables dataset. GDP has a mean value which ranges from a minimum of –4.168415 to a maximum of 3.853731 while LNBVT shows an average value range from a minimum of 9.314892 to a maximum of 21.65076. The series Jacque-Bera (JB) test for normality includes the skewness check from zero and kurtosis estimate at three, which indicates a mesokurtic distribution. GDP, FDI and ROL are negatively skewed while LNBVT, DCPS and REQ are skewed positively. All the variables exhibit platokurtic behaviour. The Jarque-Bera probability estimates show that the series is normally distributed. The number of observations indicates that there are no missing values in the series.

Table 1 Descriptive statistics

	GDP	*LNBVT*	*DCPS*	*FDI*	*ROL*	*REQ*
Mean	0.224323	15.27323	12.17223	–2.80E+09	–0.992299	–0.813426
Median	–0.204509	14.24269	12.19262	–2.65E+09	–0.989436	–0.833452
Maximum	3.853731	21.65076	14.60804	–6.17E+08	–0.871539	–0.659629
Minimum	–4.168415	9.314892	10.24658	–5.54E+09	–1.146282	–0.918893
Std. dev.	2.543774	4.914011	1.440665	1.50E+09	0.101065	0.083414
Skewness	–0.068038	0.189254	0.203273	–0.434604	–0.206308	0.669183
Kurtosis	2.171486	1.344634	1.815176	2.286278	1.579762	2.259395
Jarque-Bera	0.939937	3.844671	2.092117	1.686562	2.916440	3.119629
Probability	0.625022	0.146265	0.351320	0.430296	0.232650	0.210175
Sum	7.178331	488.7434	389.5113	–8.95E+10	–31.75358	–26.02962
Sum sq. dev.	200.5944	748.5727	64.34094	7.01E+19	0.316637	0.215693
Observations	32	32	32	32	32	32

Source: Author's compilation

Table 2 Correlation analysis

	GDP	*LNBVT*	*DCPS*	*FDI*	*ROL*	*REQ*
GDP	1.000000					
LNBVT	–0.613675	1.000000				
DCPS	–0.370429	–0.164520	1.000000			
FDI	–0.419887	0.799024	0.021876	1.000000		
ROL	–0.561706	0.942439	–0.005652	0.913793	1.000000	
REQ	0.797653	–0.586285	–0.613247	–0.602644	–0.682474	1.000000

Source: Author's construction

Table 3 Unit root test

	Augmented Dicker Fuller (ADF)					*Philip Peron (PP)*			
Variable	*T-Stat*	*At 1%*	*At 5%*	*At 10%*	*Integrated order*	*T-stat*	*At 1%*	*At 5%*	*At 10%*
GDP	–5.3058***	–3.6701	–2.9639	–2.6210	I(1)	–5.3058***	–3.6701	–2.9639	–2.6210
LNBVT	–5.9444***	–3.6701	–2.9639	–2.6210	I(1)	–5.9973***	–3.6701	–2.9639	–2.6210
DCPS	–5.2946***	–3.6701	–2.9639	–2.6210	I(1)	–5.2946***	–3.6701	–2.9639	–2.6210
FDI	–5.5045***	–3.6701	–2.9639	–2.6210	I(1)	–5.5059***	–3.6701	–2.9639	–2.6210
ROL	–5.6068***	–3.6701	–2.9639	–2.6210	I(1)	–5.6257***	–3.6701	–2.9639	–2.6210
REQ	–5.3812***	–3.6701	–2.9639	–2.6210	I(1)	–5.3812***	–3.6701	–2.9639	–2.6210

Note: (***) denotes 1% significant level.

Source: Author's conception

4.2 Correlation analysis

From Table 2, the correlation analysis between the variables is illustrated. The table presents that all the variables negatively correlate with GDP except REQ which correlates positively with GDP. This implies that LNBVT, DCPS, FDI and ROL migrate in opposing directions to GDP while REQ navigates in the same direction with GDP. The coefficients of the explanatory variables lie below 0.7 which is a standard estimate above which a coefficient signals strong correlation and multicollinearity. Thus, the regressors demonstrate no multicollinearity.

4.3 Unit root test

In Table 3, the unit root test is employed to establish the time series data stationarity which avoids spurious regression outputs using the ADF and Philip Perron (PP) tests. Time series data is considered stationary when the mean and variance remain fixed within a time period (Gujarati, 2004). The unit root test is very vital to determine the most suitable estimation model (Diehold and Kilian, 2000). Many suggestions hold that econometrics models should not be randomly employed without conducting the unit root tests to select the appropriate model for the analysis. Table 3 illustrates that all the variables are integrated of order one I(1). This is in line with the Engle and Granger residual based analytical method which presupposes co-integration checks in the series. This implies that the series are first differenced stationary I(1) with strong indication that a long run affiliation lies between the variables.

4.4 Residual based co-integration test

With the Engle-Granger residual based co-integration, any first difference stationary variables I(1) have equalised representations in the ECT and co-integration. Since the variables are order one integrated, the residual of the variables is appropriate for co-integration robustness test (Brooks, 2008). The residual based co-integration test results in Table 4 indicate that co-integration exists between crypto currency and economic growth variables. This signifies a long run connection between the variables in Nigeria. The trace or Max-Eigen statistical value of the residual-based co-integration is higher than the 5% critical value and strongly significant. Hence, the null hypothesis that no co-integration exist is rejected in favour of the alternative hypothesis. To validate the long-term relationship in the series, the fully modified OLS (FMOLS), dynamic OLS (DOLS) and conical co-integration are utilised.

Table 4 Residual based co-integration test

Unrestricted co-integration rank test (trace)				
Hypothesised no. of CE(s)	*Eigen value*	*Trace statistic*	*0.05 Critical value*	*Prob.***
None*	0.342023	11.72040	3.841466	0.0006
Unrestricted Co-integration rank test (maximum eigen value)				
Hypothesised no. of CE(s)	*Eigen value*	*Max-Eigen statistic*	*0.05 Critical value*	*Prob.***
None*	0.342023	11.72040	3.841466	0.0006

Source: Author's construction

4.5 FMOLS, DOLS and conical co-integration

Table 5 Fully modified OLS, dynamic OLS and conical co-integration

Variables	*FMOLS*	*DOLS*	*Conical co-integration*
LNBVT	–0.558086***	–0.550544	–0.571950***
	(–2.866970)	(–1.220641)	(–3.109521)
DCPS	–0.056692	–0.012290	–0.098579
	(–0.150275)	(–0.013797)	(–0.276923)
FDI	3.18E-11	–5.47E-11	9.50E-12
	(0.071175)	(–0.046852)	(0.021775)
ROL	27.93223**	28.22693	28.38783**
	(12.90299)	(0.809379)	(2.232557)
REQ	27.15597***	28.37171	26.16872***
	(7.913560)	(1.436809)	(510,401)
C	59.44312***	59.80338	59.76542***
	(15.93425)	(1.393089)	(3.779853)
R-squared	0.783876	0.881001	0.783580
Adjusted R-squared	0.740652	0.583505	0.740295
S.E. of regression	1.311570	1.711773	1.312471
Long-run variance	1.685098	3.186055	1.685098

Note: (***), and (**) represent 1%, and 5% significance levels respectively; t-statistics in parentheses.

Source: Author's assemblage

5 Discussion

In Table 5, the findings of the FMOLS, DOLS and conical co-integration regression (CCR) methods are displayed. The FMOLS, DOLS and conical co-integration are regressed with a constant and no trend. The findings unveil that LNBVT negatively and significantly affect economic growth (GDP) in the FMOLS and CCR techniques but negatively and insignificantly influence GDP in the DOLS estimation model. This result implies that LNBVT decreases economic growth in Nigeria. Furthermore, a unit increase in bitcoin volume of transaction reduces economic growth by 55.8% and 57.2% in the FMOLS and conical co-integration estimation methods respectively. The results possibly show that with an increase in bitcoin transactions, limited or no contribution is made to industrial production and other sectors to boost economic growth in Nigeria. This could be attributed to money laundry and illegal tax evasion. The findings indicate a negative long run association between LNBVT and GDP in Nigeria. The results do not align with the economic expectation as well as the findings of Holtmeier and Sandner (2019). Nevertheless, the results corroborate the findings of Oktavia and Utomo (2019). Moreover, the results disfavour the Keynesian theory and Solow's growth model which postulates continuous economic growth with a currency introduction in an economy.

DCPS insignificantly and negatively affects GDP in the FMOLS and conical co-integration estimations methods. FDI exhibits insignificantly positive influence on GDP in the FMOLS and conical co-integration estimations techniques and insignificantly negative link with GDP. The findings are not in line with the expectations. The moderating variables ROL and REQ show significantly positive influence on economic growth in the FMOLS and conical co-integration models but with insignificantly positive effect on GDP in the DOLS model. This means that the legal system and governments' REQ to promote and encourage crypto currencies is greatly indispensable in Nigeria. The regression's R-square is 78.4% in both FMOLS and CCR models with an 88.1% in the DOLS model. This reveals that the independent variables justify the variations in the explain variable at 78.4% and 88.1% in the three models.

6 Conclusions and policy suggestions

The digital currency notion is increasing daily in every economy worldwide. A digital currency stored value and it is transferred electronically. This study investigates the long-term affiliation between crypto currencies and economic growth with the aspiration to ascertain the degree to which crypto currencies transactions influence the economy in Nigeria. GDP per capita measures economic growth. BVT, DCPS, and foreign direct investment measured currency circulation with control variables being ROL and REQ. The Engle-Granger residual based co-integration, FMOLS, DOLS and conical co-integration regression. Residuals based co-integrating analysis unveils a long-term relationship is present between crypto currencies and economic growth. The regression outcomes indicate a significant negative long run association between LNBVT and GDP in the Nigerian economy.

Given the intrinsic challenges of crypto currencies, the central bank of Nigeria and the government should improve the legal system and REQ to regulate crypto currencies transactions. This research suggests that effective laws on crypto currencies transactions should be enacted and implemented to limit crypto currencies negativities in the Nigerian and global economy. This could be achieved if the crypto currencies' developers create protocols which are geographically delimited or encrypted. Additionally, this study recommends that all economic actors from households, firms and government should be open-minded towards technological innovations especially financial innovations. In a whole, the suggested policies would improve crypto currency acceptance and usage in the economies regionally and globally. Moreover, the authorities should regulate crypto currency usage, protect and secure it from fraud as well as other illegal activities. There is limited research on crypto currency nexus economic growth using Bitcoin price and other forms of crypto currencies. This study further proposes researches should be conducted on comparative study of the impact of crypto currency on economic growth of countries.

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