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Cryptocurrency Price and Exchange Rate Volatility in Nigeria

Idongesit Edem Udoh[1], Agnes Usen Akpan[2] and Abubakar Ahijo Bagudo[3]

[1]Department of Economics, Faculty of Economics and Management Sciences, University: University of Ibadan. Email: aidy4udoh@gmail.com
[2]Department of Economics, Akwa Ibom State College of Science and Technology, Nung Ukim, Ikono, Akwa Ibom State, Nigeria. E-mail: mollybaby250474@gmail.com
[3]Department of Economics, Faculty of Economics and Management Sciences, University of Ibadan, Ibadan, Nigeria. E-mail: abuhjoa@gmail.com

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Abstract: The popularity of cryptocurrencies as an alternative payment method has increased due to their decentralized structure, potential for large returns, and immunity from government controls. This study aimed to examine the impact of Bitcoin prices on Nigeria's exchange rate volatility. Data from the Central Bank of Nigeria's statistical bulletin and the US Finance Reference, covering the period from the first quarter of 2015 to the fourth quarter of 2022. A Vector Autoregression (VAR) model was used to analyse the data. The root of the character test finding reveals that the VAR model meets the stability criterion, as all roots lie within the unit circle, ensuring reliable forecasting and analysis. The impulse response function analyses revealed that Bitcoin prices (BITP) significantly impact the exchange rate (EXCR). Electronic currency level (ELEC) reveals significant early fluctuations, with an initial negative impact on EXCR but later recovered to positive values by periods 13 to 16. The financial electronic level (FINC) displays substantial early negative values, implying that an increase in FINC appreciates EXCR. The inflation rate (INFL) shows that an increase in INFL will cause EXCR to appreciate. There is a need to establish clear regulations for the cryptocurrency market.

Keywords: Bitcoin Price, Exchange Rate Volatility, Cryptocurrencies, Vector Autoregression Model, Financial Electronic Level

JEL Classification Codes: F31, E44, C32, G23

1. Introduction

Cryptocurrency and other electronic financial assets have penetrated the landscape of the economy globally. This has left most currencies to fluctuate with many witnessing serious depreciation against the US Dollars. Experts in finance and economics have recently become interested in the widespread use and acceptance of Bitcoin and other cryptocurrencies as an alternative method of payment (Jimoh and Benjamin, 2020). Even when cryptocurrencies are volatile, the acceptance rate and usage inside the global financial system are growing. This is owing to their decentralized structure, potential for large returns, and

immunity from stringent government controls. They have also grown in popularity as a financial instrument among both individuals and corporations (Abdullahi and John, 2023).

The concept of Bitcoin originated from perceived shortcomings in the monetary and financial systems, encompassing large financial entities as well as the subjective decision-making involved in monetary policy (Karau, 2021). More than ten years ago, Nakamoto (2008) introduced the concept of cryptocurrencies by describing Bitcoin as a decentralized electronic monetary system. Bitcoin, according to Nakamoto (2008), is the first peer-to-peer decentralized blockchain network. This means that users, not a bank or other authority, are in charge of managing the entire network, which is made up of a list of transaction information arranged chronologically within each block.

Since the launch of Bitcoin in 2009 following the 2008 financial crisis, Bitcoin has experienced tremendous growth (Nakamoto, 2008), which was first used in illicit trade, most significantly on the Silk Road. In 2013, the cryptocurrency blockchain was briefly split, which was resolved when the bulk of the network reverted to the Bitcoin software version 0.7. US bitcoin miners who sell their coins fall under FinCEN restrictions as Money Service Businesses. In 2018, there were hacks on exchange rates including Coincheck, Coinrail, Bithumb, and Bancor, which had a negative impact on the price of Bitcoin. In 2017, Bitcoin Classic was split from Bitcoin Cash, which also witnessed an increase number of users. For transaction security, Bitcoin uses hash currency proof-of-work and cryptographic methods including asymmetric cryptography and hash functions. Asymmetric cryptography is used to associate every Bitcoin transaction with a public key. Bitcoin may be acquired in a variety of ways and is used for four different types of transactions: mining, trading, investing, and commerce. Bitcoin wallets enable blockchain transaction verification by storing private keys and addresses.

One of the newest and most innovative products on the market is a digital currency known as Bitcoin (Gopane, 2018). Anyone can use the Bitcoin cryptocurrency and digital payment system anywhere in the world (Liu and Serletis, 2019). Transactions take place directly between parties in a peer-to-peer network, eliminating the need for middlemen. Every transaction is verified by a node network before being entered into a blockchain, a publicly accessible distributed ledger. Every Bitcoin transaction is available to the public through the blockchain. (Almagsoosi et al., 2022).

The impact of cryptocurrency on monetary policy may vary, including increased competition, less control over the money supply, currency control,

and better financial inclusion (Karau, 2021; Benigno, 2022). Owing to its decentralisation, cryptocurrencies are not as susceptible to the monetary policy tools used by traditional institutions, such as currency in circulation or changing interest rates, as fiat currencies are. Furthermore, due to increasing competition, cryptocurrencies may put pressure on central banks to maintain the strength and stability of their currencies. Cryptocurrencies, such as Bitcoin, are based on their decentralized software system and constant supply, which also manages the exchange rate and prevents inflation. Blockchain-based cryptocurrencies such as Bitcoin had notable surges in market capitalization and transaction volume in 2017, contributing to their rise in popularity.

The ability to use Bitcoin as a mechanism for payment hinges on miners, who take charge of providing records and validating transactions. Because of the limited manageability of the Bitcoin system, a significant number of transactions can generally be recorded. In comparison to other financial assets, Bitcoin presents huger volatility. From January 2014 to June 2021, the daily returns of Bitcoin in United States Dollars (USD) had a standard deviation of more than 4%. This is eight times bigger than the USD/Euro exchange rate and four times higher than the S&P 500. (Yermack, 2013; Auer and Tercero-Lucas, 2021; Auer, et al., 2022; Deniz and Stengos, 2020)

The transferability of Bitcoin by anybody, anywhere, and value is controlled on various currency exchanges. Although cryptocurrency markets with prices in several fiat currencies offer speculative opportunities. Factors such as capital hindrances, including price risk and transaction costs contribute to the significant variations in Bitcoin pricing. Arbitrage trades can be challenging to execute owing to capital restrictions, processing delays, withdrawals and deposit fees, and the need for capital via the traditional financial system to repatriate gains, (Kroeger and Sarkar, 2016). It is intriguing to note how spreads respond to changes in monetary policy, as magnitude and duration vary across currencies and periods. Such an examination would demonstrate if the post-shock spike in demand for Bitcoin is consistent with other currency markets. Cryptocurrency use in Nigeria has been criticized in several ways, the most common being that it is connected to illegal activities (Elusoji, 2021; George, 2024).

The Central Bank of Nigeria (CBN), on many occasions, has placed restrictions on Bitcoin activities in Nigeria. Specifically, in February 2021, the bank has forbidden the sale and exchange of cryptocurrencies, including its acceptance as a means of payment in a letter to banks and financial institutions. The CBN also mandated banks to stop individuals or companies from managing cryptocurrency exchanges or trading accounts. This was owed to the illegality

of cryptocurrencies as cash that are produced by unlicensed and unregistered businesses, mainly outside Nigeria. The CBN further underlined the exposure of currencies to illicit use, including money laundering, financing terrorism, and currency speculations owing to their anonymity and lack of know-your-customer (KYC) (Nwanisobi, 2021). Additionally, Nigeria's National Security Adviser (NSA) in May 2024 ordered the thwarting of users' cryptocurrency accounts and reporting of those transactions to law enforcement, labelling Bitcoin trade as a national security concern (Olowogboyega, 2024)

Despite the government of Nigeria's ban on cryptocurrency use, Bitcoin is widely used in Nigeria, hence this ban is meaningless. Peer-to-peer trading, or direct money transactions between members, has become the norm in the Nigerian cryptocurrency ecosystem. With 60,215 Bitcoins transferred for almost $566 million in the last five years, Nigeria now has the highest volume on Paxful, the largest peer-to-peer Bitcoin marketplace in the world, after the United States (Ekpu, 2020, Paxful, 2020). According to Coin-Dance data from 2020, there was a least 19% growth in the volume of Bitcoin exchanged in Nigeria annually. The largest volume (20,504.50) was moved during the pandemic's peak in 2020 (Coin Dance, 2020, Uba, 2021). Between January and September 2020, Paxful recorded a 137% rise in new registrations in Nigeria (Paxful, 2020).

Nigeria is currently the top-ranked country in the world for persons searching for "Bitcoin" and "Crypto" on Google, with over 6.3 percent of the population owning a cryptocurrency of some type (Ayadi et al., 2024). According to the Chainalysis 2021 Global Crypto Adoption Index, Nigeria has adopted cryptocurrencies at a rate that ranks sixth out of the top 20 countries (Chainalysis Team, 2021). Cryptocurrency adoption is escalating in Nigeria, Kenya, and other emerging countries, according to Chainalysis, because of a few important variables. Nigerians are reported as most use peer-to-peer (p2p) cryptocurrency exchanges as their entrance point into cryptocurrencies because they are unable to access centralized exchanges. Furthermore, Nigerians use cryptocurrencies to conduct business, send and receive remittances, and protect their funds from currency depreciation. Reuter (2023) found that in 2022 and 2023, many Bitcoin users in Nigeria received more USD. From July 2022 to June 2023, Nigeria experienced a 9% annual growth in cryptocurrency transactions, amounting to $56.7 billion, which indicates that Bitcoin is booming in Nigeria, despite being banned.

Between 2010 and 2013, the value of Bitcoin in Nigeria was quite low, with prices ranging from $0.09 to $13.3. Nevertheless, there were notable ups and downs, and the technology became more well-known. The price increased to

$754.22 in 2014, but subsequently fell to $314.25 in 2015 and $434.33 in 2016. Bull markets have been linked to the 2014 Bitcoin halving events, which lower the incentive for mining new blocks. The price increased to more than $900 in 2017. 2018 saw an extraordinary spike in interest in Bitcoin, with prices approaching $13.637.20. This gain was accompanied by a rise in both institutional and retail engagement. Nevertheless, there were large market losses as the price saw a momentum decline to $3,843.52 in 2019 and $7,200.17 in 2020. Bitcoin saw another significant upswing in 2021 and 2022, topping the previous all-time high with prices of $29,374.15 and $47,686.81, respectively. But the market also saw heightened regulatory scrutiny and sporadic corrections, which caused the price of Bitcoin to drop to $16,625.08 in 2023.

From 2010 to 2023, the Naira to USD exchange rate has fluctuated significantly. In 2010, the average exchange rate was N150.30/$1, which increased to N153.86/$1 in 2011 and N157.50/$1 in 2012, before a slight appreciation to N157.31/$1 in 2013. However, the exchange rate rose sharply in the following years: N186.10/$1 in 2014, N196.99/$1 in 2015, N295.00/$1 in 2016, N306.92/$1 in 2017, N309.92/$1 in 2018, N358.81/$1 in 2019, N401.98/$1 in 2020, N425.41/$1 in 2021, and N633.83/$1 in 2023. Several factors have influenced the value of the Naira relative to the US Dollar, including the activities of the Central Bank of Nigeria (CBN), fluctuations in oil prices, the foreign investment climate, and capital flows. One major factor contributing to the Naira's devaluation has been speculation on Bitcoin and other cryptocurrency platforms. Speculative trading, especially p2p trading, is believed to manipulate the Naira through a pump-and-dump technique, resulting in the currency prohibition by the CBN (Olowogboyega, 2024). To stabilize the Naira, the CBN has employed various strategies, including direct market interventions and imposing restrictions on the amount of foreign currency available for specific import categories. In addition, the Nigerian government, through the CBN, has fixed the nation's exchange rate to prevent further devaluation. The CBN's efforts to control the exchange rate reflect a broader strategy to mitigate the impact of external factors and speculative trading on the Naira's value.

Even without specific tax regulation covering cryptocurrencies, the Federal Inland Revenue Service (FIRS) announced that Bitcoin transactions will be subject to capital gains taxation (Jooji et al., 2023). Recently, FIRS has changed the charge against Binance, Gambaryan on four counts bordering on alleged tax evasion (Nseyen, 2024). Although scholars have examined the impact of cryptocurrency on various aspects of the economy (Dumitrescu et al., 2023; Abdullahi and John, 2023; Chang et al., 2021), the widespread acceptance of

Bitcoin has brought a new dimension to Nigeria's economic landscape. The CBN has persistent concerns about the potential impacts of cryptocurrencies on the Naira exchange rate and other monetary policy variables leading to increased concern. This concern is heightened by the lack of comprehensive empirical studies examining these impacts. Specifically, how Bitcoin transactions and assets inspire exchange rate volatility, inflation, and other financial variables remains under-researched. This study aims to comprehensively examine the impact of Bitcoin price on Nigeria's economic landscape, with a particular focus on its impact on the exchange rate volatility in Nigeria.

2. Literature Review

The credit theory of money, as propounded by Walras (1954) and Simmel (1978), emphasizes the difference between money and the objective of money. According to this theory, money is not made of tangible entities, it is rather a social concept that functions concerning other commodities. The concept of "trust" in this study denotes the social function of money, which is assigned more weight in the credit theory of money. The welfare state's role in urging the growth of the economy and market failure compensation was examined from various perspectives by the political economy paradigm. Geoffrey Ingham argues that money is essentially nothing more than a "promise to pay" between people and is created by certain social relations that are independent of the production of goods and services. The proponents of the credit theory of money believe that states can create an entity to value money based on the "trust" that is comprehensible from the exchange of money.

The use of fiat money began in Europe after World War I when central banks persuaded governments to allow them to keep the borrowed gold instead of declaring commercial banks insolvent, as seen by the history of monetary policy over time. Franklin Roosevelt in 1933, used a similar scheme in the US to estimate the total market commodity and indicate that the dynamics of "underlying economic realities" are suitable for intertemporal preferences, which requires a theoretical model. Market models describe how spontaneous order came into being and offer the underlying epistemological postulations on our lack of access to sufficient knowledge. The market serves as a process of promoting group collaboration within the division of labour, via the disclosure of personal subjective values. This kind of system can only be developed by unifying and facilitating the production, distribution, and collection of information on the preferences of the general public, or what is known as the "market."

Since the government's forceful intervention in the price of goods and services upsets an established order, individual preferences may not be represented in objective pricing. Demand for a commodity will rise and customer behavior will change if the objective price of a product does not meet consumer desires. Since the supply of this extra demand does not match the desires of the goods suppliers, the government will have to act more to bring order to this chaotic situation. The concept of the "capacity to store value" is central to the definition of money as a medium of exchange. This quality is significant when it results in greater happiness while facing future uncertainties. If cryptocurrencies promise to maintain their subjective value over time and demand that certain current products be abstained from, then they may be able to store value. Even though the value of this method is more unpredictable compared to that of other commodities, individuals have deliberately chosen it.

The subject of whether cryptocurrencies may be used as a unit of account can be seen from several angles. First of all, it should be mentioned that cryptocurrencies and other commonly used fiat currencies have traits such as homogeneity, diversity, and availability.

Cryptocurrencies have a greater influence on the relative value stability of fiat currencies. The pricing objective, expressed in monetary units with the aim of enhancing recognition and comprehension, reflects the intertemporal preferences. It is necessary to take into account the relative value stability of cryptocurrencies while choosing the best option for holding value over time and location. The relative cost of fiat currencies is determined using inclusive currencies since goods and services must be exchanged for other currencies. Cryptocurrencies can be used to determine the value of currencies of countries if they find new uses and gain popular acceptance. Owing to cryptocurrencies' greater use and confidence, they become more traded and have a greater capacity to hold value, making them a more dependable and stable unit of account. Some cryptocurrencies, as opposed to fiat currencies like the dollar, have shown better performance as an accounting unit even in the face of double-digit rates of inflation by retaining their relative value stability in regard to goods and services. Behaviour portfolio theory presents alternate or improved versions of the capital asset pricing model postulated by Sharpe (1964) and Lintner (1965), as well as Shefrin and Statman's (2000) behavior portfolio theory. To take into consideration variables other than an asset's return, the arbitrage pricing theory employs a linear relationship between an asset's predicted return and macroeconomic indicators. According to Li and Wang (2017), macroeconomic variables impact cryptocurrencies, which makes arbitrage pricing theory a more thorough method

of determining the drivers and prices of bitcoin. Corbet et al. (2019) found that Bitcoin is not included in the capital asset pricing model; instead, it solely explains the return on the first two assets.

Studies have investigated Bitcoin and other financial issues. For example, a study by Riska-Dwi and Nadia (2018) examines how Bitcoin affects the currency rate in China, and how it accounts for current account, inflation, and money supply fluctuations while using the volatility of Bitcoin prices as an independent variable, employing Autoregressive distributed lag (ARDL) on monthly time series data between 2012 and 2017. Findings from the study reveal that in the long -run, Bitcoin price volatility impacts the exchange rate, with higher volatility correlated with higher risk. The negative symbol implies that real currency investments can be preferred by investors in order to benefit from the exchange rate.

Guizani and Nafti (2019) in their study examine the major factors that influence the price of Bitcoin, using time series data spanning from 2011 to 2018, the researchers employed the Granger causality test, cointegration test, and ARDL model as methods of analysis. Findings from the study reveal that attractiveness index, mining difficulty, and address count have an impact on the price of Bitcoin in the short- and long-run.

The Bitcoin exchange rate (BER) is influenced by various factors like human speculation and policies, and its fluctuation is dependent on the financial system according to Chang et al. (2021), whose study establishes a Vector Autoregressive (VAR) model for BER, providing a framework for the Google search volume index (SVI), investor fear gauge (VIX), and the S&P500 Index. The study reveals a Granger causality feedback relationship between BER and Google SVI and a significant relationship between VIX and BER in the long-term co-integration.

A study by Abdullahi and John (2023) examines how the performance of companies listed on the Nigerian Exchange Limited (NGX) is affected by the volatility of cryptocurrencies. Findings reveal that bitcoin trading in Nigeria reacts more to positive emotion and good news than bad news, using an ex post facto research approach and the GARCH (1,1) model. The variance equation indicates that earlier shocks and volatility circumstances had an impact on the conditional volatility of cryptocurrencies today as well as the performance of the companies. In addition, the analysis reveals indications of volatility clustering in the NGX performance of the companies. According to the research, authorities, and legislators should employ pertinent indications to reduce the risk of contagion, and investors should proceed with prudence in the burgeoning cryptocurrency sector, which the Nigerian government's intention to launch an official virtual currency depends on.

Jimoh and Benjamin (2020) investigate the connection between Nigeria's stock market price, exchange rate, and the two most traded cryptocurrencies, Ethereum and Bitcoin, using the Granger causality test, EGARCH 1, and GARCH 1 algorithms with data from August 2015 to December 2019. Findings indicate that the price volatility of Bitcoin and Ethereum has a greater impact on stock market prices than Nigeria's exchange rate. Additionally, the study reveals a one-way causal relationship between the all-share index and Bitcoin and Ethereum.

Dumitrescu et al., (2023) studied the impact of Bitcoin returns on the development of national currencies in nine European non-euro nations, taking into account a number of control factors, including interest rate differentials, business confidence, inflation differentials, and the COVID-19 pandemic. The findings indicate a negative link during the pandemic, an increase in the price of Bitcoin causes the value of other currencies to appreciate, concluding that changes in the price of Bitcoin impact monetary policy through the exchange rate channel.

Using the GARCH model, Kufo et al. (2024) investigate the effects of trading volume, information demand, stock returns, and exchange rates on the volatility of decentralized and unbacked cryptocurrencies from 2016 to 2022. Findings revealed that the decentralized and unbacked cryptocurrencies are positively correlated with trade volume, information demand, and exchange rates; while unaffected by the stock market returns of the MSCI ACWI world stock index. The study provides an avenue for investors to make judgments about portfolio optimization by providing insights into the volatility of bitcoin returns.

Using data from September 2019 to September 2021, Ibikunle and Akutson (2022) examined how cryptocurrency volatility affects Nigeria's foreign exchange market. The effect of foreign exchange returns on the price returns of four of Nigeria's biggest cryptocurrencies is ascertained using the VAR-Multivariate GARCH analytical framework. Findings revealed that foreign exchange has a beneficial impact on the average spillovers of cryptocurrencies, and further discovered that historical mistakes in the foreign currency market are susceptible to outside volatility. The study concluded that cryptocurrencies are useful instruments for hedging against financial uncertainties and suggested low-leverage contracts and appropriate diversification tactics to avoid the high risks connected with cryptocurrencies, which are prone to volatility.

Employing daily data from December 2019 to June 2021, Mallick and Mallik (2023) examine the relationship between cryptocurrencies and Indian currency foreign exchange rates, employing multiple regression analysis, Durbin-Watson, and correlation analyses. Findings from the study indicate that there is no meaningful correlation between the cryptocurrency exchange rate and the Indian

currency exchange rate, with the exception of YEN and Ethereum; and USD, Binance Coin, and Litecoin. Nonetheless, there was a strong positive correlation between Bitcoin and Binance Coin, Ethereum and Binance Coin, Binance Coin and Litecoin, and Litecoin and Binance Coin.

Afiyanu et al. (2022) investigate how Bitcoin affects Nigeria's exchange rate, utilizing the ARDL analysis on monthly time series data spanning from January 2015 to December 2020, Findings reveal that the short- and long-term exchange rate is highly impacted by the price of Bitcoin. As a result, the study advises Nigeria's authorities to keep an eye on the fluctuations in cryptocurrency values.

3. Methodology

This study uses secondary data from the Central Bank of Nigeria's statistical bulletin and the US Finance Reference from the first quarter of 2015 to the fourth quarter of 2022, to carry out quantitative analysis. To investigate how Bitcoin price, affects the exchange rate in Nigeria, the VAR model econometric technique is used. We will use a single multiple regression model to examine how globalization affects income inequality in Nigeria.

This study uses the VAR model to determine the individual impact of bitcoin price (BITP), electronic currency level (ELEC), financial electronic level (FINC), and inflation (INFL) on the exchange rate (EXCR) in Nigeria. The derivation of the VAR model based on the variables can be set up in a system of equations where each variable is expressed as a linear function of its own lagged values and the lagged values of all other variables in the system.

The general form of a VAR Model is specified in equation (1) below. The equation shows a VAR model with k variables and p lags which is written as:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \mu_t \quad (1)$$

Where:

Y_t is a vector of all endogenous variables at time t.

c is a vector of intercept terms.

A_i are matrices of coefficients for each lag i.

μ_t is a vector of error terms at time t.

The specific VAR model for the given variables is defined below.

$EXCR_t$: Naira/US Dollars Exchange Rate at time t

$BITP_t$: Bitcoin Price at time t

$ELEC_t$: Electronic Currency Level (a function of *((M1 – M0)/M2)* money) at time t

$FINC_t$: Financial Electronic Level (a function of ((*M2 – M0)/M2)* money) at time *t*

$INFL_t$: Inflation rate at time *t*

The VAR(1) model (with 1 lag for simplicity) can be written in a matrix form as:

$$\begin{pmatrix} \mathrm{EXCR}_t \\ BITP_t \\ ELEC_t \\ FINC_t \\ INFL_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{pmatrix} + \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{12} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{pmatrix} \begin{pmatrix} \mathrm{EXCR}_{t-1} \\ BITP_{t-1} \\ ELEC_{t-1} \\ FINC_{t-1} \\ INFL_{t-1} \end{pmatrix}$$

The matric can be written out in the equations explicitly for each variable in the expansion form as shown in equations (2) to (6):

Exchange Rate (EXCR):

$$EXCR_t = c_1 + a_{11}EXCR_{t-1} + a_{12}BITP_{t-1} + a_{13}ELEC_{t-1} + a_{14}FINC_{t-1} + a_{15}INFL_{t-1} + \mu_{1t} \quad (2)$$

Bitcoin Price (BITP):

$$BITP_t = c_2 + a_{21}EXCR_{t-1} + a_{22}BITP_{t-1} + a_{23}ELEC_{t-1} + a_{24}FINC_{t-1} + a_{25}INFL_{t-1} + \mu_{2t} \quad (3)$$

Electronic Currency Level (ELEC):

$$ELEC_t = c_3 + a_{31}EXCR_{t-1} + a_{32}BITP_{t-1} + a_{33}ELEC_{t-1} + a_{34}FINC_{t-1} + a_{35}INFL_{t-1} + \mu_{3t} \quad (4)$$

Financial Electronic Level (FINC):

$$FINC_t = c_4 + a_{41}EXCR_{t-1} + a_{42}BITP_{t-1} + a_{43}ELEC_{t-1} + a_{44}FINC_{t-1} + a_{45}INFL_{t-1} + \mu_{4t} \quad (5)$$

Inflation (INFL):

$$INFL_t = c_5 + a_{51}EXCR_{t-1} + a_{52}BITP_{t-1} + a_{53}ELEC_{t-1} + a_{54}FINC_{t-1} + a_{55}INFL_{t-1} + \mu_{5t} \quad (6)$$

The VAR models in equations (2) to (6) capture the dynamics among exchange rate, bitcoin price, electronic currency level, financial electronic level, and inflation. Each equation represents how the current value of a variable depends on its past value and the past values of all other variables in the system. This allows for the analysis of how shocks to one variable can propagate through the system over time.

3.1 Root of Character

In VAR models, stability is a crucial property that ensures the model's forecasts and simulations do not diverge over time. A VAR model is considered stable if

all the roots of its characteristic equation lie inside the unit circle in the complex plane. This condition ensures that shocks to the system will eventually dissipate and the system will return to equilibrium, rather than exhibiting explosive behavior.

The unit circle in the complex plane is the set of all points that are at a distance of one unit from the origin. In mathematical terms, if λ represents an eigenvalue of the matrix, the stability condition requires $|\lambda|<1$.

For a VAR model, the characteristic equation is derived from the determinant of a matrix polynomial associated with the model. The roots of this equation (also known as eigenvalues) determine the model's stability. The characteristic roots (or eigenvalues) of the VAR model for the system involving exchange rate, bitcoin price, electronic money, financial electronic level, and inflation, are derived below.

Given a VAR(1) model:

$$Y_t = c + A_1 Y_{t-1} + \mu_t \tag{7}$$

where Y_t is a vector of the endogenous variables at time *t*:

$$Y_t = \begin{pmatrix} \mathrm{EXCR}_t \\ BITP_t \\ ELEC_t \\ FINC_t \\ INFL_t \end{pmatrix}$$

and A1 is the coefficient matrix of lagged variables:

$$A_1 = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{12} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{pmatrix}$$

The characteristic roots can be determined by expressing the VAR(1) model in its companion form is given in the matric equation below:

$$\begin{pmatrix} Y_t \\ Y_{t-1} \end{pmatrix} = \begin{pmatrix} A_1 & I \\ 0 & 0 \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ Y_{t-2} \end{pmatrix} + \begin{pmatrix} \mu_t \\ 0 \end{pmatrix}$$

For our specific case, we expatiate the matric equation as shown below:

$$\begin{pmatrix} EXCT_t \\ BITP_t \\ ELEC_t \\ FINC_t \\ INFL_t \\ EXCR_{t-1} \\ BITP_{t-1} \\ ELEC_{t-1} \\ FINC_{t-1} \\ INFL_{t-1} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & 1 & 0 & 0 & 0 & 0 \\ a_{21} & a_{12} & a_{23} & a_{24} & a_{25} & 0 & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & 0 & 0 & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & 0 & 0 & 0 & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} EXCT_{t-1} \\ BITP_{t-1} \\ ELEC_{t-1} \\ FINC_{t-1} \\ INFL_{t-1} \\ EXCR_{t-2} \\ BITP_{t-2} \\ ELEC_{t-2} \\ FINC_{t-2} \\ INFL_{t-2} \end{pmatrix} + \begin{pmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \\ \mu_{5t} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The characteristic equation is then found by solving the determinant of $\lambda I - A$, where A is the companion matrix given in equation (8):

$$\det(\lambda I - A) = 0 \tag{8}$$

Here, I is the identity matrix of appropriate dimension, and $ë$ represents the eigenvalues we are seeking.

The characteristic polynomial obtained from the determinant is then solved to find the roots (eigenvalues). For the matrix equation in the companion form, we solve to obtain the eigenvalues:

$$\det \begin{pmatrix} \lambda & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & \lambda & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & \lambda & 0 & 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & \lambda & 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & \lambda & 0 & 0 & 0 & 0 & -1 \\ -a_{11} & -a_{12} & -a_{13} & -a_{14} & -a_{15} & \lambda & 0 & 0 & 0 & 0 \\ -a_{21} & -a_{12} & -a_{23} & -a_{24} & -a_{25} & 0 & \lambda & 0 & 0 & 0 \\ -a_{31} & -a_{32} & -a_{33} & -a_{34} & -a_{35} & 0 & 0 & \lambda & 0 & 0 \\ -a_{41} & -a_{42} & -a_{43} & -a_{44} & -a_{45} & 0 & 0 & 0 & \lambda & 0 \\ -a_{51} & -a_{52} & -a_{53} & -a_{54} & -a_{55} & 0 & 0 & 0 & 0 & \lambda \end{pmatrix}$$

The solutions to the characteristic polynomial give the eigenvalues of the system. If any eigenvalue has an absolute value greater than 1, the system is not stable.

3.2. Impulse Response Function (IRF)

The IRF traces the effect of a one-time shock to one of the innovations μ_t on the current and future values of the endogenous variables Y_t. It provides a way to visualize the dynamic response of each variable in the VAR system to a shock in any variable. By iterating the VAR model forward and computing the impact at each horizon, we can derive the IRF and understand the time path of the variables following a shock.

Computing the IRF requires the moving average (MA) representation of the VAR model. This can be obtained by iterating the VAR model forward as shown in equation (9) below:

$$Y_t = \mu_t + A1\mu_t - 1 + A12\mu_t - 2 + A13\mu_t - 3 + \ldots + A1h\mu_t - h \tag{9}$$

The IRF at horizon !h for a shock to the jth variable is given by the j-th column of $1hA1h$.

In the case of a VAR(1) model, the IRF at horizon !h is computed in equations (10) to (13) below. Here, we assume the impact of different horizons and periods.

At the initial impact (h=0), the model is given in equation (10) below:

$$(0) = IRF(0) = 1 \tag{10}$$

At one period ahead (h=1), the model is given in equation (11) below:

$$(1) = IRF(1) = A1 \tag{11}$$

At two periods ahead (h=2), the model is given in equation (12) below:

$$(2) = 12IRF(2) = A_2^1 \tag{12}$$

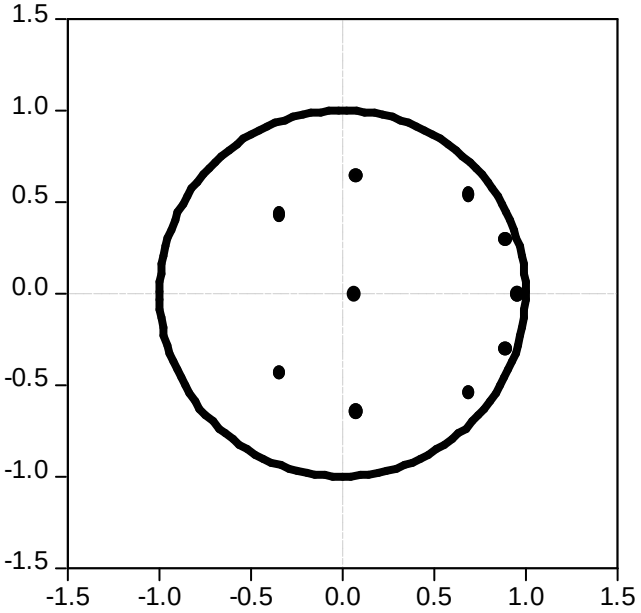
In a general form where (h=h), the model is given in equation (13) below:

$$(h) = 1hIRF(h) = A_h^1 \tag{13}$$

This process is continued for the desired number of periods. The resulting matrices give the response of each variable in Y_t to a shock in each variable.

4. Data Analysis, Result Interpretations, and Discussion of Findings

The roots of the characteristics of the VAR model in this study are examined here. Figure 1 above provides evidence of stability in the VAR model by showing no root lies outside the unit circle, hence, a modulus of less than one. Since all values are less than one, it indicates that the model meets the stability criterion, as it has no eigenvalue outside the unit circle. This finding suggests that the



No root lies outside the unit circle.

VAR satisfies the stability condition.

Figure 1: The Root of Character Results

VAR model does not exhibit non-stationary behavior, which would have been problematic for reliable forecasting and analysis.

Figures 2–5 show the periods over which the analysis is conducted on the X-axis. The Y-axis values represent the responses of EXCR to each variable (BITP, ELEC, FINC, INFL) across periods (1 to 32), as determined by the Impulse Response Function (IRF) in a VAR model.

From the figure, BITP at the initial periods starts at 0 and increases gradually over time. It peaks around periods 10–12, reaching the highest value at period 11 (7.056920), which suggests that an increase of bitcoin price by one percent resulted in an increase in the Naira/US Dollars exchange rate by 7.056920%. It declines after the peaks and starts to decrease but remains positive throughout the entire period. The increase in Bitcoin prices in the initial periods suggests a growing interest or investment in Bitcoin, which can impact the exchange rate by influencing capital flows. The peak around period 11 and subsequent stabilization indicate that the impact of Bitcoin on the exchange rate might be strong initially but stabilizes over time. Increased Bitcoin adoption can lead to an increase in the demand for foreign currency according to Chodorow (2018),

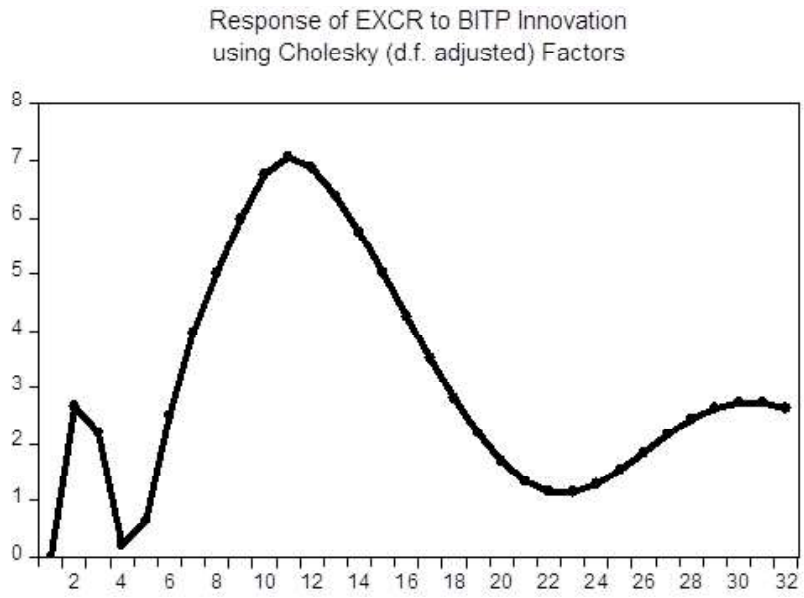


Figure 2: Response of EXCR to BITP Innovation using Cholesky (d.f. adjusted) Factors

affecting the Naira exchange rate. This result conforms with the work of Dumitrescu et al. (2023)

At the initial periods, ELEC starts at 0 and shows significant fluctuations. It later has a negative impact with negative values in early periods (e.g., -5.028374 in period 7), implying that an increase in ELEC by one unit will reduce EXCR by 5.028374%. It steadily recovered with values becoming less negative and eventually turning slightly positive in periods 13 to 16 revealing a unit increase in ELEC will increase EXCR. The significant fluctuations and negative values suggest volatility in the ELEC, which can affect the exchange rate by impacting the cost of importation and external balance. The gradual recovery in later periods indicates stabilization, which could lead to a more stable exchange rate as ELEC stabilizes, affecting importation and investment. This aligns with Kroeger and Sarkar's (2017) finding, which indicates the related relationship between ELEC fluctuations and EXCR volatility, particularly in how it impacts import costs and external balance in emerging markets.

The FINC initial period begins at 0 and shows significant negative values early on (e.g., -9.261754 in period 5). This implies that if FINC is increased by 1%, EXCR will appreciate by 9.261754%. The severe negative values early on suggest financial stress or tightening conditions can lead to an appreciation of the exchange rate as capital inflows increase or foreign investment increases. The reduction in negative values over time indicates an increased demand for

money and the electronic level of financing, which could lead to a weaker exchange rate. This gradual reduction in negative values over time indicates some stabilization of the exchange rate. This finding conforms with IMF. Middle East and Central Asia Dept. (2022) study found that financial tightening affects the economy.

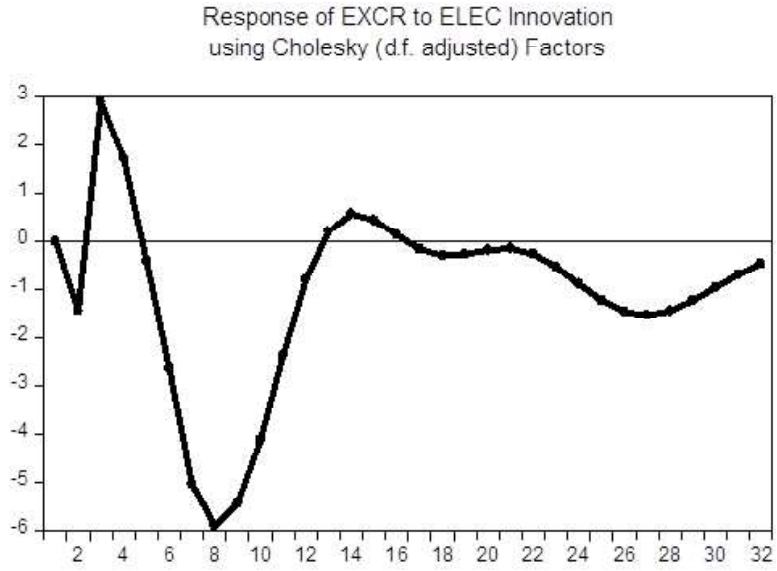


Figure 3: Response of EXCR to ELEC Innovation using Cholesky (d.f. adjusted) Factors

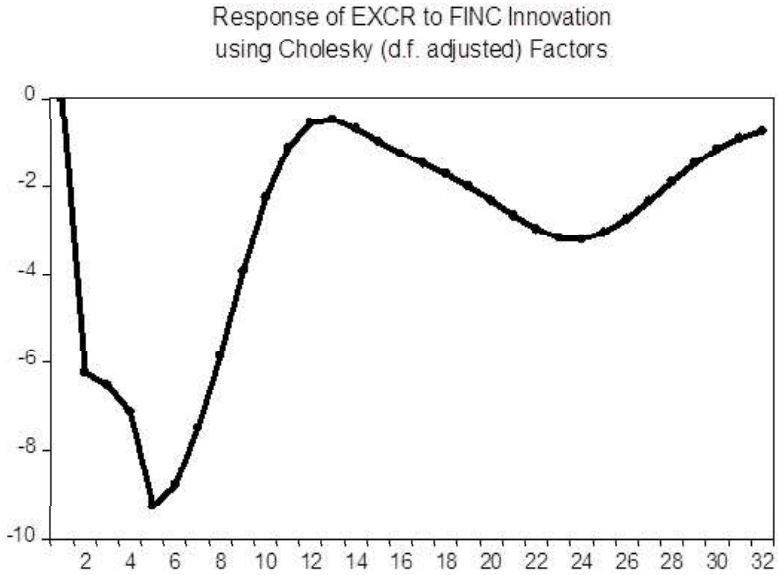


Figure 4: Response of EXCR to FINC Innovation using Cholesky (d.f. adjusted) Factors

INFL at initial Periods also starts at 0 and becomes negative quickly with the highest negative value of -2.707325 in the 12 period. This means that if INFL increases by a unit, EXCR will appreciate (fall) 2.707325%. The reduction in the negative impact of INFL over time indicates some stabilization in the EXCR. The consistent negative values in the early periods indicate that inflationary pressures are having a positive impact. High inflation typically leads to appreciation of the exchange rate as the purchasing power of the currency increases. The diminishing negative impact over time suggests that inflationary pressures are easing, which could help stabilize the exchange rate. This finding conforms with Ahmed and Zlate's (2014) finding which reveals that inflationary pressures can initially lead to exchange rate appreciation because of increased currency purchasing power, however, may stabilize over time as inflationary impacts contracts.

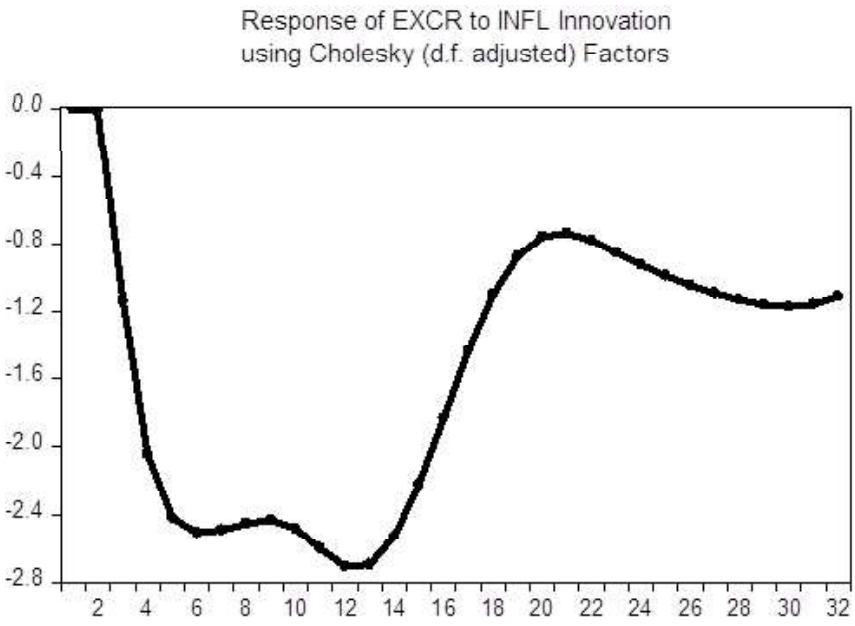


Figure 5: Response of EXCR to INFL Innovation using Cholesky (d.f. adjusted) Factors

5. Conclusion

This study examines the impact of Bitcoin prices on the exchange rate in Nigeria between the first quarter of 2015 to the fourth quarter of 2022. Other variables, such as electronic currency levels, financial electronic levels, and inflation rate were included in the model as independent variables. Findings from the study

reveal that while initial shocks and volatility are present, there is a trend toward stabilization and recovery over time. Bitcoin price reveals a significant initial positive response with the exchange rate, peaking during mid-term and stabilizing, suggesting that Bitcoin price influence may be strong initially but levels off over time. Inflation concerns suggest persistent adverse impacts on the exchange rate, although these impacts do contract slightly over the long term. Findings also revealed that the general impact on the exchange rate is short-term volatility owing to the initial increase in Bitcoin prices and severe financial stress. Mid-term stability occurs when Bitcoin prices peak and stabilize, financial conditions improve, and electronic currency recovers, suggesting a period of adjustment where the exchange rate might start to stabilize. Long-term stability is expected with stable Bitcoin prices, improved financial currency level, and reduced inflationary pressures. The study recommends the need to stabilize Bitcoin and other cryptocurrency prices by establishing clear regulations, and licensing requirements, enforcing compliance with anti-money laundering and counter-terrorist financing regulations, and promoting transparency and responsible investment practices in the cryptocurrency market.

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