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The Effect of Crypto currency Returns and Volatility on the Exchange Rate: Evidence from Nigeria

by

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Abstract

Given the increasing trade in cryptocurrencies across the globe and its use as a medium of exchange and means of settlement of debts in countries, this dissertation examines the effect of cryptocurrency return and volatility on the naira – United States dollar exchange rate in Nigeria during the period 2015 to 2021, while controlling for economic activity or gross domestic product (GDP) and oil prices. By adopting the GARCH-MIDAS regression approach which uses mixed-data frequencies and the Diebold-Yilmaz Spillover index, the results suggested that cryptocurrency return and volatility have significant effects on the Naira to one United States dollar exchange rate in Nigeria, with evidence of permanent and consistent effects in the long run.

The results from the GARCH-MIDAS regression suggested that changes (increase or decrease) in the Bitcoin and Dash coin cryptocurrency return and volatility would lead to a change (depreciation or appreciation) of the Nigerian Naira currency, while, an increase(decrease) in the Ethereum return would lead to a change (appreciation or depreciation) of the Naira currency. Furthermore, in relative terms, the effect of a change in Bitcoin returns and volatility was stronger than those of the Ethereum and Dash coin cryptocurrency return and volatility. In addition, results from the Diebold-Yilmaz spillovers revealed that the net effect of the Bitcoin cryptocurrency was positive in both returns and volatility, suggesting that the Bitcoin cryptocurrency transmitted more than what it received from other variables outside the model. For the Dash coin, the net effect was positive only in returns but negative in volatility, suggesting that in volatility, the Dash coin transmitted fewer shocks than what it received. The net effect of Ethereum on the Naira - United States dollar exchange rate was negative in both return and volatility, suggesting that although changes in Ethereum return and volatility affected the Naira- United States dollar exchange rate in Nigeria, what it received was higher than what it transmitted to the other variables outside the model.

These findings have therefore provided insights into operations in the cryptocurrency market and would serve as a good guide to the monetary policy formulation processes in Nigeria, whose main policy objectives included achieving a stable exchange rate in order to spur output growth and sustainable development in Nigeria

Key words: cryptocurrency, exchange rate volatility, GARCH-MIDAS, Nigeria, Diebold – Yilmaz index

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1.0 Background to the Study

The last three decades have witnessed an increasing trend, not only in the mining and use of cryptocurrencies, but also in their adoption by individuals, business, and governments worldwide. This development has led to the introduction of several cryptocurrencies into the financial market landscape and since 2009, when the bitcoin cryptocurrency was first introduced, several others have continued to be added to the list of cryptocurrencies, while some are being edged out of the market. The continued growing interest in the mining and use of cryptocurrencies has posed a sustained challenge to monetary and financial authorities, as most of the operations in the cryptocurrency marketplace are outside the purview of these authorities. The challenges are growing as more individuals and businesses units continue to engages in economic and financial transactions that involve changing their local currencies with some unit of a cryptocurrency, thus affecting not

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only the local currency exchange rate and money demand but also the general level of prices in the long run. Since the mining and use of a cryptocurrency is not controlled by any monetary or financial authority but individual miners through the blockchain, understanding their operations and effect on macroeconomic aggregates like the exchange rate, money demand and inflation becomes pivotal to unravelling the smokescreen behind the growing interest in the use and adoption of cryptocurrencies during the last three decades. We provide a brief background behind the growth in the use and adoption of cryptocurrencies, which will provide a basis for defining and stating our research problem, specifying the research objectives and questions, hypothesis to be tested and by what method we seek to achieve them.

More recently, there has been a growing interest in the mining and introduction of new cryptocurrencies since the introduction of the bitcoin in 2009. These are although, cryptocurrencies are not issued by central banks or Governments or have legal tender status, individuals and business units not only use them but countries worldwide, have been adopting some these cryptocurrencies as means of payments and medium of exchange in their jurisdictions. Generally, Cryptocurrency transactions are easy, reliable, and convenient but slow in gaining acceptance by individuals and businesses and, in getting adopted by countries. Despite these developments, there are countries that have either adopted the bitcoin cryptocurrency as a means of payment, although not necessarily as a medium of exchange, while others are considering either to give it some form of recognition or to adopt the bitcoin along with one or two other cryptocurrencies for the purpose of settlement of its financial transactions and payments. In some other countries, they have introduced own digital currency or electronic digital money, while in others they have either restricted the use of cryptocurrencies or imposed an outright ban on the use of cryptocurrencies within their jurisdictions. The nature of activities in the cryptocurrency market place and the high volatility in cryptocurrency prices and returns, created loopholes for several illegal activities that have led to fraud and loss of money to some market participants and organizations.

Since the introduction of the bitcoin as the first cryptocurrency some thirteen years ago, the cryptocurrency marketplace and industry has continued to grow in both market capitalization and volume due to the sustained relative rise in prices. According to data on Global cryptocurrencies as provided by the coinmarketcap.com website2, the number of cryptocurrencies grew from about two in 2009 to 5,200 on July 28, 2021, and 6,015 on August 13, 2021. Similarly, total market capitalization in United States dollar also rose from almost nothing in 2009 to a worth of US$1,700,060,032 on April 30, 2013 to US$11,367,199,744 on 19th January 2014; US$17,522,499,584 on 3rd January, 2017; US$244,946,201,804 on 1st March, 2020; US$910,851,741,750 on 22nd January 2021 and US$2,340,112,782,857 on 6th May, 2021. Also, the total volume of transactions in the cryptocurrency market likewise grew from a US$ 99.93 million on April 30, 2013 to US$51,685,900 on 19th January 2014; US$434,128,992 on 3rd January, 2017; US$131,697,916,668 on 1st March, 2020; US$191,870,547,014 on 22nd January 2021 and US$253,170,329,966 on 6th May, 2021. The Global cryptocurrency market has maintained a sustained growth pattern over last three decades, such that by 29th December, 2021, the number of cryptocurrencies had risen to 16,132 different cryptocurrencies that were operating on 447 cryptocurrency exchanges and controlling a market capitalization that was valued at US$2,251,162,988,487 with approximately total daily volume of transactions valued at US $95,011,882. The observed trend in the growth of cryptocurrencies and the activities associated with them, was found to be correlated with continued declines in the use of cash and revenues from credit card transactions, declines in revenues from transfer services and loss of control of financial markets by supervisory and regulatory agencies like Central banks, Supervisory Agencies and Security and Exchange Commissions (PWC, 2015).

In central banking, where the amount and value of the money demand by the individuals and economic units for their day-to-day obligations should correspond with the amount and value of money supplied in the economy is controlled and regulated by the government or monetary authorities, the introduction of a cryptocurrency would affect the efficacy of monetary policy instruments in achieving the desired monetary policy objectives and outcomes. This is true because use of the cryptocurrency in the economy would affect the amount of money stock or local currency holdings individuals and businesses units would be willing to hold, as they exchange part of their local currency holdings with some units of the cryptocurrency, in order to either safeguard against inflation or to diversify the assets in their investment portfolios. Whenever such a situation occur in an economy, the number of units of the local currency being exchanged for one unit of a foreign currency or exchange rate and the number of units of the local currency demanded in the economy would be affected. These developments are possible, because in demanding some units of the cryptocurrency, the individual or business unit can obtain such a cryptocurrency from the trader or seller, only if such a demand is made effective or is backed by the ability to buy or a purchasing power.

[2] See https://coinmarketcap.com

Since cryptocurrencies are traded on cryptocurrency exchanges, whose operations are outside the purview of the monetary and regulatory authorities of the country's financial system, the effect of their activities have largely remained uncaptured or unregulated. Since activities in the cryptocurrency markets would impact both exchange rates and money demand, it is also expected that those effects, except insulated by the monetary and regulatory authorities could translate into higher prices. The resultant effect of cryptocurrency activities on the advanced and developing countries are likely to be similar, since the cryptocurrency operations occur across borders irrespective of national boundaries. It is important to note however, that even though these effects might be similar, they should differ due to presence of other factors, especially the peculiarity of each country or economy. For the many developing and emerging market economies of Europe and sub-Saharan Africa whose economies are interconnected and where inflation is largely associated with general and sustained changes in money supply, the impact of activities in the cryptocurrency market would have likely spillover effect.

The challenge to the monetary and regulatory authorities therefore would be how to closely monitor and capture developments in the cryptocurrency market to monitor and regulate activities in the market and thereby improve on their ability to achieve the stated monetary policy goals and objectives. It is expedient to note that, for many countries, the goals and objectives of monetary policy are set by the monetary authorities or central bank in collaboration with the fiscal authorities or government at the beginning of every fiscal financial year. That means that, in a country where its economic units are engaged in the use of a cryptocurrency as a medium of exchange and means of payment, challenges are created for the monetary authorities or central banks in realizing their monetary policy goals and outcomes. This implies that central banks should not only know which cryptocurrencies are held by its individuals and economic units. what sectors of the economy they are being invested or traded but must also be aware on when those cryptocurrency transactions are consummated and what associated challenges holding those cryptocurrencies would have on the macroeconomy.

In today's mainstream, a variety of cryptocurrencies are in existence, with each having their own challenges. However, the one with the largest market capitalization and acceptability is said to be the bitcoin (Wan, et al., 2014). The bitcoin is a digital currency invented in 2008 and operates a peer-to-peer system where individuals pay for transactions undertaken by both parties. It eliminates intermediaries like the deposit money banks (DMBs) and other financial institutions that ensure the transfer and processing of funds between parties engaged in those economic transactions. The bitcoin is seen as the 'gold standard' of digital currencies in the cryptocurrency market. As a cryptocurrency, the bitcoin carefully incorporates the strengths of commodity money and the convenience of fiat money and frees itself of the challenges of both forms of money. A characteristic of bitcoin is that it cannot be inflated artificially, or have its supply increased or decreased by activities of monetary authorities. Transactions within the cryptocurrency network environment are enlisted in a public ledger known as the "block chain".

The block chain is a giant public database where bitcoin transactions are recorded and maintained by a decentralized network of miners. The miners validate and process the transactions and are rewarded with bitcoins priced at prevailing rates (Nakamoto, 2008). Whenever a new transaction is secured, a block is added to the block chain and the reward of 25 bitcoins credited into the miners account and with an addition of transaction fees of all transactions in the chain. Theses rewards are usually given to the miner that, in the quickest time, hashed a block (Khan, 2014). The bitcoin supply has been set at 21 million units and is usually traded online at platforms like Bit finex, BTC China, Coinbase, or Bit stamp. On these platforms, individuals trade paper currency or fiat money, with the bitcoin at the prevailing exchange rate (Nakamoto, 2008; Wan, et al., 2014) Despite the advancement and benefits associated with cryptocurrencies, the ability of the bitcoin and other cryptocurrencies to circumvent financial institutions, its level of price volatility, the nature of decentralized control of transactions and the close link with the level of technology, create serious challenges for the supervisory and regulatory authorities in most of the countries they are used, including Nigeria, whose level of technological advancement and financial services infrastructure are generally underdeveloped and poor

1.2 Statement of Research Problem

The increasing globalization of financial and monetary systems along with technological innovations and advancements in payments and settlement systems have triggered the digital revolution and developments of new financial assets and instruments, especially the creation of new forms of money like the cryptocurrency, which are outside the purview of central banks and governments. The emergence and use of cryptocurrencies as "money" worldwide, have posed concerns amongst economic agents including policy makers, economists, investors, bankers, consumers, governments, and regulators as to whether the use of a bitcoin cryptocurrency would lead to the end of fiat money. It has also created a vacuum for risk management, portfolio analysis and

consumer sentiment, while its use worldwide confirm the ability of cryptocurrencies to affect not only liquidity, portfolio diversification and arbitrage (Glaser et al. 2014, Gandal and Halaburda, 2014), but also the payment and settlement systems as well as monetary policy outcomes of countries.

Since the development of the bitcoin in 2008, an asset that has come to be regarded as the most widely used cryptocurrency, several other crypto assets have continued to be developed and added to the web of financial assets. The introduction of bitcoin was motivated by the desire to bridge the gap and resolve the inefficiencies embedded in the traditional use of money or fiat currency and other fiat forms of currencies. This is because most cryptocurrencies like bitcoin, are claimed to be cheaper and faster to mint and have wider coverage in both advanced and developing market economies, including those of sub-Saharan Africa. In Nigeria, as the cryptocurrency market remains unregulated and more and more Nigerians continue to embrace its use and acceptance, especially in the Bitcoin and Ethereum cryptocurrencies, the Supervisory and Regulatory agencies like the Securities and Exchange Commission (SEC), the Nigeria Deposit Insurance Corporation (NDIC) and the Central Bank of Nigeria (CBN) are poised with enormous challenges on how best to mitigate the risks from cryptocurrencies on the economy. These institutions and agencies appear to be carefully monitoring developments in the cryptocurrency market place with some these agencies already issuing cautionary warnings to participants in the cryptocurrency market. In analyzing the effect of cryptocurrency returns on the naira- United States dollar exchange rate, money demand and Inflation in Nigeria, it is imperative to carefully explain some key concepts that underline a proper understanding of cryptocurrency operation. These include the blockchain technology, peer-to-peer transactions, proof-of- work, deregulated finance, digital currency or electronic money, crypto wallet, crypto asset and cryptocurrency returns. This is important because the block chain technology involves several disciplines[3] and so defining these key terms would help us appreciate the nature of activities in the cryptocurrency markets and the operations of cryptocurrencies within a decentralized framework, and better understand the challenges cryptocurrencies poise to regulators, especially central banks, who are expected to monitor and regulate their activities in the cryptocurrency market.

Furthermore, it is evident that, the use of cryptocurrencies and the high volatility associated with its returns is creating uncertainties and policy challenges to the supervisory and regulatory authorities of the financial system, especially the central banks who have been forced to miss their monetary policy targets and policy outcomes. This study seek to investigate the extent to which changes or volatility in cryptocurrency returns like the bitcoin, Ethereum and Dash Coin returns. have affected the amount of money demanded by Nigerians at any given point in time, the number of units of the Naira local currency exchanged for one unit of the United States dollar or a unit of a foreign currency and the level of domestic prices or inflation in the Nigerian economy during the period 2015 to 2021. In addition, the study would try to establish how these developments have constrained the Central Bank of Nigeria's (CBN) ability to effectively deliver on its core mandate[4] of price stability and sustainable economic growth in the country.

1.3 Research Questions

The study would be guided by two research questions;

i)What effect does cryptocurrency returns and volatility have on the Nigerian Naira – United States Dollar exchange rate? and

ii)How does that development affect the monetary policy goals and outcomes of the Central Bank of Nigeria?

1.4 Objectives of Study

The broad objective of the study is to examine the effects of cryptocurrency returns and volatility especially those of (bitcoin, Ethereum and dash Coin) on the exchange rate of naira – US dollar, money demand and inflation rate in Nigeria. Specifically, the study seeks to;

i) Analyze the effect of the bitcoin, Ethereum and the Dash coin cryptocurrency return and volatility on the Naira to one United States Dollar exchange rate and,

ii) Evaluate how the development has impacted on the efficacy of the monetary policy goals and outcomes of the Central Bank of Nigeria and to make policy recommendations on how best to address future occurrences.

1.5 Research Hypotheses

The hypotheses for the study are stated in the null form and would be tested at the 5% level of significance.

[3] For example, Computer Science, Engineering Technology, Finance and Economics

[4] These mandates are clearly stated in the CBN Act of 2007 as amended.

H01: Bitcoin, Ethereum and Dash Coin Cryptocurrency return and volatility have no significant effect on the Nigerian Naira – United States Dollar exchange rate

H02: Bitcoin, Ethereum and Dash Coin Cryptocurrency return and volatility have significant effect on the efficacy of the monetary policy goals and outcomes of the Central Bank of Nigeria.

1.6 Significance of Study

The study would be significant to the academia, policy makers and practioners in the money and capital markets of developing and emerging economics in the following ways; first, it will make an original contribution to the existing body of knowledge on the effect of cryptocurrency return and volatility from the bitcoin, Ethereum and the Dash Coins on the value of the Nigerian Naira or number of units of the Naira being exchanged with one United States Dollar currency in an oil exporting, import -dependent, developing and emerging market economy like Nigeria. The study also presents empirical evidence from daily and monthly data covering August 2015 to December 2021, which to the best of my knowledge, has never been documented in previous studies. The findings from the study would guide policy makers in their decisions on how best to use and adopt a cryptocurrency in a developing oil exporting, import dependent emerging market economy like Nigeria. It would also provide empirical evidence that may lead to revisiting major policy decisions already taken on the use and adoption or otherwise of cryptocurrencies by governments or its agencies. The study will also serve as a reference material for future research in this area.

1.7 Scope of Study

The study is set out to examine the effect of cryptocurrency return and volatility especially those from the Bitcoin, Ethereum and Dash Coins on three selected macroeconomic variables of the Nigerian Naira to one United States Dollar exchange rate in Nigeria using mixed data sampling covering the period August 2015 to December 2021. It will identify an appropriate technique of economic analysis to test the data, within the available constraints of both economic. Statistical, financial and the Academic calendar at the Nile University of Nigeria. The selected time period for the study was based on availability of data and other study limitations

This research would be presented in five sections. Section one would focus on the background to the study, with subsections on statement of the research problem, research questions, objectives of study, statement of hypotheses, significance of the study, scope of the study, and organization of the study. Section two would review the relevant literature and would include explanation of some basic concepts used in the cryptocurrency literature, theoretical framework behind the research and empirical review of relevant studies on the subject matter. Section three would present the method of the study and would cover things like, the type and sources of data, choice of method for the analysis of data, specification of the models and list of variables in the model, a priori expectations and limitations of the model. Section four would present and discuss the empirical results of data analyzed and the interpretation of the implications of the results on the monetary policy goals and outcomes of the Central Bank of Nigeria. Section five would summarize the study, conclude on the major findings emerging from the findings and make recommendations for future policy. It would also highlight the contribution to knowledge, limitation of the study as well as identify the areas for further research.

2.1 Literature Review

2.1.1 The Institutional Framework[5] for Monetary Policy Formulation

The decision-making process of formulating and implementing monetary policies by central Banks varies from country to country, although with some common features. Specifically, the processes involve the evaluation of economic and financial data or review of recent developments of key macroeconomic variables in the economy to provide background information on the policy environment as well to help the management of the central Bank take appropriate and timely monetary policy actions. The main issues involved in the monetary policy process include; the institutional arrangements for the decision-making process which could be through a central Bank Board or the Monetary Policy Committee (MPC); the composition of the Board and MPC; the frequency and schedule of meetings of the Board or MPC; the nature of the central Bank's independence (i.e. whether operational and or goal independence); how actual decisions are taken at the Bank's meetings (i.e. whether through the casting of votes or consensus building); and, the strategy for communicating monetary policy decisions to market agents, among others.

[5]A description of the institutional framework for the operation of monetary policy in Nigeria is given is Appendix 1.

Each Country adopts a formulation and implementation strategy that best suits its peculiarity and economic setting. We highlight below the process and institutional arrangements for monetary policy management in Nigeria. The process of formulating monetary policy is coordinated by the CBN, although the actual process is shared among various government agencies including the Presidency, the Federal Ministry of Finance (FMF), Federal Ministry of Budget and National Planning (FMBNP) and the Debt Management Office

In Nigeria, at the beginning of every fiscal financial year, the Central Bank of Nigeria will through the Monetary Policy Department (MPD), on behalf of the Monetary Policy Committee (MPC) and the Central Bank of Nigeria,, prepare the Monetary Policy Programme (MPP), usually titled, "Monetary, Credit, Foreign Trade and Exchange Rate Policy Guidelines for Fiscal ------". The MPD collates inputs from relevant departments within the Bank and prepares the MPP or medium-term monetary policy programme covering a period of two to three years. The MPD computes the relevant monetary aggregates within a financial programming framework and estimates, using the simple monetary rule, the required amount by which money supply should grow, if the Federal Government's inflation and growth targets are to achieved. They also identify the policy instruments that will be best suited for achieving the specific targets on a monthly, quarterly and annual basis. The MPD then forwards the MPP to the Monetary Policy Implementation Committee (MPIC) through the Monetary Policy Technical Committee (MPTC), who screens the proposal and return same to the MPD, who then summon a meeting of the MPC. After the MPC has discussed and vetted the MPP, it is sent to the Committee of Governors (COG), who ratifies the document before forwarding it to the CBN Board for approval. It is when the Board has approved the MPP that it is sent to the President for integration into the nation's annual budget.

The President will after be adding their input, forward the Monetary Policy Programme (MPP) to the National Assembly (NASS) as part of the Federal Government's Executive budget bill. When the NASS passes the bill into law and is accented to by the President, it is sent to the Federal Ministry of Finance for implementation. It is important to note that due to the changing statue of the CBN, the Ministry had at several times in the Bank's history, participated in foreign exchange management, bank licensing and supervision of banks. By the 1991 and 1999 amendments to the CBN Act, the conduct of monetary policy management was consolidated within the CBN. However, as an agency of government, the CBN performs its monetary policy management functions through the MPC and Monetary Policy Implementation Committee (MPIC) in consultation with the relevant government ministries and agencies. The Governor also sends other documents to the President/NASS for information. These include the half year economic report, monthly reports on foreign exchange developments and on monetary and financial sector developments.

2.1.2 The Institutional Arrangements for Monetary Policy

The power to formulate and implement Monetary Policy is vested in the hands of the Monetary Policy Committee (MPC). The Monetary Policy Committee (MPC) was established in 1999 as the focal point for the formulation of monetary policy within the CBN. According to section six of the CBN Act of 2007 No. 7, which stipulates for the establishment of a Board for the Central Bank, it says that, "there shall be for the Bank a Board of Directors (in the Act referred to as "the Board" which shall be responsible for the policy and general administration of the affairs and business of the Bank". The CBN Act went further to specify that the Board shall consist of :-

a) The Governor, who shall be the Chairman
b) four Deputy Governors
c) The Permanent Secretary, Federal Ministry of Finance
d) Five Directors; and
e) Accountant General of the Federation.

The Central Bank of Nigeria Board was charged with the following responsibilities.

a) The consideration and approval of the annual budget of the Bank
b) The approval of the audited and management accounts and the consideration of the management letter from the external auditors
c) The formulation and implementation of exchange rate policy
d) Making recommendation to the President for the appointment of Auditors in accordance with section 49 of this Act, the provision of necessary facilities and the rates of renumeration
e) The establishment and closing of branches and currency centres
f) Carrying out of such other activities as are necessary and expedient for the purpose of achieving the objectives of the Bank

The Act also provides that, "the Board shall approve the detailed responsibilities of each of the Deputy Governors on the recommendation of the Governor, and that, without prejudice to Sub-section (4) of that section of the CBN Act, the Board may, on the recommendation of the Governor, assign or re-assign the Deputy Governors, from time to time, as may be expedient for the performance of the Bank's functions under or pursuant of this Act. The Act further provides that, the Governor or in his absence, one of the Deputy Governors nominated by him, shall be in charge of the day-to-day management of the Bank and shall be answerable to the Board for his acts and decisions. The Act also provides that the provisions for the establishment of the Bank shall apply in relation to the general policies pursued by the CBN or policies intended to be pursued on any administrative matters including staff pensions, salaries, allowances sand any other similar matters. It also provides the qualifications and renumerations of the Governor and Deputy Governors, their services to the Bank, and the appointment of Board Directors of the Central Bank, which shall be done by the President of the Federal Republic of Nigeria and approved by the Nigerian Senate. The Act also provides conditions and situations whereby a Board Director of the Central Bank can be removed or disqualified. The Act also provides for the establishment of the Monetary Policy Committee (MPC)whose sole function shall be to formulate monetary policy as well as coordinate and monitor its implementation among the various arms of the Federal Government, especially the fiscal and other authorities. The Monetary Policy Committee (MPC) has the main responsibility of formulating monetary and credit, trade and exchange rate policies of the Government with a view to facilitating the attainment of price stability and supporting the economic policies and programmes of the Federal Government of Nigeria. The MPC is the Committee to facilitate the attainment of the Bank's objective of price stability and to improve the process for monetary policy formulation and implementation.

The memberships of the MPC was drawn from both within and outside the Bank, so as to enhance the quality of monetary policy, introduces transparency and credibility, as well as facilitate monetary policy transmission mechanism. The Act also provides that the membership of the Monetary Policy Committee (MPC) shall comprise twelve members, namely:

a) The Governor of the Bank who shall be the Chairman.
b) The four Deputy Governors of the Bank;
c) Two members of the Board of Directors of the Bank;
d) Three members appointed by the President; and
e) Two members appointed by the Governor.

The MPD acts as Secretariat to the MPC and coordinates all the meetings. The MPC meets at least four times in the year and publishes its calendar of meetings on the CBN website. The Governor or in his absence, the Deputy Governor in charge of monetary policy may summon a meeting of the MPC giving not less than seven days' notice. For the MPC to meet, six members, two of whom shall be the Governor and a Deputy Governor, or two Deputy Governors shall constitute a quorum. Decisions are taken by vote of all those present at the meeting and in the event of a tie, the Chairman shall have a second or casting vote. The MPC submits a periodic report of its meetings and activities to the Board of Directors of the Bank.

Since the inception of the MPC, Nigeria's monetary policy management has been evolving for the better. In 2003, the MPC curved out the Financial Services Surveillance Committee (FSSC) with a view to focusing more of its discussions on banking sector-related policies. The FSSC Secretariat is located with the Banking Supervision Department. The composition of the MPC was modified in 2004 when a technical arm, the Monetary Policy Technical Committee (MPTC) was formed. Other agencies that meet regularly to provide input for the MPC and MPIC are the liquidity forecasting group, the fiscal liquidity assessment group, the monetary policy forum and the monetary policy advisory group (see appendix for an overview of their functions) In addition, in 2006, the Monetary Policy Implementation Committee (MPIC) was also formed. The MPIC meets on any other day to take decisions of how much liquidity to mop-up or eject into the system and with what instruments. The MPIC is chaired by the Deputy Governor, Economic Policy, with the Directors of Monetary Policy, Research and Statistics, Trade and Exchange, Banking Operations and Banking Supervision as members. Membership of the MPTC is similar to that of the MPIC but at the Directors level. Membership of the MPTC is similar to that of the MPIC but at the Directors level.

The decisions of the MPC are communicated to the public through the issuance of a monetary policy communiqué. This is consistent with the global acceptance of the principles of the Code of Good Practices on Transparency on Monetary and Financial Policies of the IMF. The publication of the MPC decisions help to minimize the problem of information asymmetry and fosters market confidence, which is essential for macroeconomic stability, greater accountability and sustained credibility in monetary policy. The effective

communication of monetary policy decisions has been found to enhance credibility by building a good reputation for the central bank. Although the Bank has made some progress in recent times, challenges exist in view of Nigeria's fast integration into the global financial landscape. Other supporting committees of the MPC includes the Fiscal Liquidity Assessment Committee (FLAC) which comprise of all revenue generating and spending agencies of the Federal Government and meets weekly at the Central Bank of Nigeria to review activities in the previous week and consider the inflows and outflows of the coming week and evaluate their implications on the National economy. Such considerations are weighed against agreed targets, current and expected releases as well as the impact of developments in the international crude oil market and developments in the international economic and financial marketplace on the Nigerian economy. The FLAC collects data on expected Federal Government revenues and estimated expenditure warrants and releases and then use them to simulate within a financial policy and planning framework, the effects of policy shocks on the National economy and use these results to advise and guide the policy direction of government.

2.2 Review of the Empirical Literature

2.1.1 Review of Studies on Cryptocurrencies and The Economy

The empirical review of the literature for this study is focused mainly on studies on the effect of the Bitcoin, Ethereum, and Dash coin cryptocurrencies on the Naira United States dollar exchange rate, demand for money, and inflation, paying particular interest to studies from emerging and developing economies. We shall use it to know what has been done and which method helped them to produce the results, what was their strengths and weaknesses and the lessons we need to learn from them. Due to the paucity of studies that directly addresses our topic, we shall rely on the few related studies on cryptocurrencies and the macroeconomy and use them as a guide to our study.

Cornelli (2018) in a study on the relationship between six cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Monero and Dash Coins) with the United States Dollar exchange rates and eight fiat currencies (Euro, Australian Dollar, Indian Rupee, Swiss Franc, Malaysian Ringgit, Thai Baht, Taiwan Dollar, South African Rand, New Zealand Dollar, Chinese Yaun and Japanese Yen) in the Asian financial market reviewed the nature of causality in their relationships. They used both descriptive statistics and the logarithmic form of the multivariate linear regression functions to identify the nature of relationship between the daily data of six selected cryptocurrencies in the Asian Financial Market and eight fiat currency exchange rates covering the period 28th April 2013 and 7th March 2018. The model used multivariate regression model with the cryptocurrencies as dependent variables and the exchange rates as independent variables. The logarithmic transformation of each equation was taken and each significant coefficient identified and the nature of granger causality also applied for all the stationary variables, while the vector error correction model was used for the non-stationary variables. The Multivariate regressions shows strong correlations between each cryptocurrency and some of the fiat currencies and it was these relationships that was used for the granger casualty test. All the cryptocurrencies were found to be related to one or more currency exchange rates, except for the Australian and New Zealand Dollars and the South African Rand. Surprisingly, the Thai baht and Taiwan Dollar were found to be correlated with all the cryptocurrencies and that, the Asian currencies appear to be driving the major cryptocurrencies in the world, although in a bidirectional manner.

Also, Al-Naif (2020) analysed the relationship between the top three cryptocurrencies of the Bitcoin, Ethereum, and Ripple and the daily exchange rates of eight Arabian currencies namely Egyptian Pound, Iraqi dinar, Lebanese Lira, Moroccan Dirham, Omani Riyal, Qatari riyal, Saudi Arabian Riyal, and Tunisian Dinar against the United States Dollar during the period 1stJanuary 2017 and 1st January 2020. The authors used statistical methods of multiple regression, unit root test and correlation coefficient to decipher the type of relationship between the daily movements in the Bitcoin, Ethereum and Ripple cryptocurrencies and the eight selected Arabian fiat currency exchange rates. The results found no significant relationship between the eight Arabian currencies and the three cryptocurrency exchange rates, except for the Lebanese Lira with Bitcoin and Ripple, Moroccan Dirham with Ethereum, and the Iraqi dinar with Ripple, which indicated a significant positive relationship between the variables of concern. The study was of the view that, since there was a negative relationship between Ripple and Iraqi dinar, the later can benefit from hedging and diversification and that developments in the Arabian countries exchange rates does not influence developments in Arabian currency markets.

In a study on the effect of cryptocurrency returns on the stock market and exchange rates in Nigeria, Sodiq Olaiwola Jimoh et al. (2021) used the Generalized Autoregressive Conditional Heteroscedasticity (GARCH 1,1), Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH 1,1) and the Granger causality methods to examine the effect of volatility in monthly cryptocurrency returns on the exchange rates

and stock market prices during the period August 2015 to December 2019. Their results indicated that while volatility in the Bitcoin and Ethereum returns influenced stock market prices in Nigeria, they had no effect on the exchange rate. In terms of direction of change, the authors found a one way causality between the Bitcoin and Ethereum cryptocurrency returns to the all share index but none from the cryptocurrency returns to the exchange rate. The results of this study is of interest to us, especially because of the lack of influence of the Bitcoin and Ethereum returns on the Naira-United States dollar exchange rate in Nigeria.

2.1.2 Models for Estimating Volatility in Cryptocurrencies Returns and volatility

Guglielmo Maria Caporale and London Timur Zenoah (2018) reviewed a thousand GARCH- type volatility models to estimate returns from Bitcoin, Ethereum, Ripple and Litecoin and to establish which model best explains the log of exchange rate. For the best fit GARCH model, the lowest Akaike (AIC), Bayesian (BIC), Human-Quinn and the LM test criterium were applied and after a rigorous analysis of the data, the study concluded that, based on the empirical evidence, the GARCH (1, 1) model was the best fit model for estimating exchange rate returns. In another study that sought to establish which GARCH method would be good at estimating the effect of Bitcoin cryptocurrency on macroeconomic variables, Glaser et al. (2014) and Gronwald (2014) reported that, an autoregressive GARCH would better fit the Bitcoin data than the standard GARCH. In terms of separating the effects of negative from positive variances, Dyhrberg (2016) usedan asymmetric GARCH model to sort out volatilities in Bitcoin prices and concluded that the GARCH method was useful in helping investors hedge, because it guided them in separating negative from positive variances. Similarly, Katsiampa, P (2018) examined GARCH[6] type models to ascertain which of them would better estimate volatility in Bitcoin prices. The study identified the autoregressive GARCH- type model as the most appropriate for describing and predicting volatility in returns from bitcoin prices. The model gave the best fit for bitcoin, thus accounting for both short- and long-term volatilities of the conditional variance. In a related study, Bauwens et al. (2010, 2014) however cautioned that, where there are structural breaks, the GARCH (1, 1) model would perform poorly. In such rare cases, the Markov-Switching GARCH (MS-GARCH) model would do better in estimating exchange rate return, Studies by Wilfling (2009) and Bohl et al. (2011). Ardia et al. (2018) also tested for the presence of regime changes in GARCH-type models of volatility in Bitcoin prices using regime switching. The results indicated that, Bitcoin returns and volatility changes from MS-GARCH models produced good results than the standard GARCH models.

Osterrieder, Lorenz, and Strika (2016) studied the effect of returns from the Bitcoin and other cryptocurrencies and provided both statistical and extreme value analyses of returns from some important cryptocurrencies. The study focused on estimating the tail risk characteristics of the cryptocurrency and using univariate and multivariate extreme value analysis. The tail dependence of cryptocurrencies was investigated using Gaussian copulas method to analyze extreme value behavior of cryptocurrencies, their correlations and tail dependencies as well as their statistical properties. The findings showed that cryptocurrencies exhibited strong non-normal characteristics and large tail dependencies depending on the particular cryptocurrency under study. That statistical similarities were observed between cryptocurrencies that shared the same underlying technology. The results revealed varying implications of cryptocurrency returns for risk management and financial engineering, especially when trading with derivatives on those cryptocurrencies.

2.1.3 Review of Central Bank of Nigeria Study on Cryptocurrency

In May 2021, the Governor's Office of the Central Bank of Nigeria undertook one of the most comprehensive and detailed study[7] on, "Cryptocurrency as an Emerging Medium of Exchange and its Effects on Central Banking: - A Report of a Collaborative Study", The study, which was the first of its kind in Nigeria used the questionnaires method of obtaining information and combined it with personal contact through conferences and workshops that involved a sample population of 521 attendees, out of which 467 of whom returned their completed questionnaires. Several conferences and workshops were held in the cities of Abuja, Lagos, Jos, Kaduna, and Port Harcourt. The questionnaires was administered both offline and online to participants, who were largely young graduates between the ages of twenty-one and forty, and who were either unemployed graduates or were engaged in various businesses, entrepreneurs, and civil servants that needed to supplement their income. The survey was said to have covered "all participants in the cryptocurrency ecosystem operating in Nigeria", which included Miners, Users, Exchanges, service providers, Software developers, market

[6] This included the Linear, threshold, exponential, asymmetric power, power, Component multiple and conditional heteroscedastic GARCH models

[7]Note the whole of this section of the review is based on the CBN study, titled "Cryptocurrency as an Emerging Medium of Exchange and its Effects on Central Banking: - A Report of a Collaborative Stud", May 2021,

operators, technical analyses, Chart providers, and businesses or merchants that had accepts cryptocurrencies. The cryptocurrencies that were found to be the most traded in Nigeria were Bitcoin and Ethereum.

According to the unpublished Central Bank of Nigeria (2021) report, the crypto-currency industry in Nigeria is "dominated by exchanges, wallets, mining, banks and brokerage services". In terms of cryptocurrency uses, most of the respondents bought and sold cryptocurrencies for investments, purchases of online goods and services, and cryptocurrency trading. In terms of how they were held, Thirty-seventy- seven (37) of the total respondents held their cryptocurrencies in wallets; twenty-three 23) held them in exchanges, seventeen (17) in payment services, twelve (12) in mining, two (2) in brokerage services and zero- point nine (0.9) held in cryptocurrencies in Banks. In addition, about seven (7) participants were not ready to disclose how they held their cryptocurrencies, preferring anonymity.

In terms of segmentation, about seventy-seven-point six percent (77.6) of the cryptocurrency industry players were dominated by exchanges, wallets, and payments and that, while the exchanges and stockbrokers provided the platforms for users to buy and sell cryptocurrencies, the wallets provided secured storage and provided exchange services to customers buying and selling cryptocurrencies. The CBN (2021) report also noted that, cryptocurrency activities in Nigeria did not go through the Banks but rather through, "the decentralized blockchain technology", which enabled users to buy and sell items without going through the deposit money banks. It noted that most users engaged in cryptocurrency trading in Nigeria were for investment purposes, possibly to hedge against inflation, and that such behavior was not peculiar to Nigeria, because it appear to be the trend globally The study also showed that, fifty-four (54) percent of respondents that patronized the Coinbasemarketcap.com, used the Bitcoin cryptocurrency to diversify their investment portfolios, while twenty-four (24.7) percent used their cryptocurrencies to make online purchases of goods and services and twenty-four (24.3) percent bought and sold other cryptocurrencies, Furthermore, the CBN study disclosed that, about seventy-seven (77) percent of respondents maintained that they have been recording gains, while twenty-three (23) percent admitted incurring losses. The amount traded by these participants was said to have ranged from less than half a million naira to over five million Naira. The study concluded that with the growing interest to hold and trade in cryptocurrency in Nigeria, the increasing innovation in financial technology, and in the blockchain technology, the cryptocurrency market is bound to gain more acceptance and usability in Nigeria and beyond the West African sub-region. The challenge is for the supervisory and regulatory authorities to come up with policy options that would better maximize the gains, while mitigating likely adverse effects on the Nigerian economy. The study specifically stated that,

> "with increased public confidence in cryptocurrencies and the fact that they potentially provide a credible alternative to conventional fiat money, which means that economic policies, such as conventional monetary policy, would have to be fine-tuned for effectiveness, especially for the control of inflation, money laundering, and illegal transactions"

The study then concluded that, due to the decentralized nature of cryptocurrency operations and the increasing number of Nigerians embracing cryptocurrency trading, the monetary, regulatory, and supervisory authorities like the Central Bank and Securities and Exchange Commission, would have to keep on fine-tuning their policy measures and instruments so as to maximize the benefits and mitigate the risks associated with the use and adoption of cryptocurrencies in Nigeria.

2.2 Theories of Exchange Rate Determination

Although numerous theories have been propounded on the determination of exchange rates worldwide, a lot remains to be done on specific studies an oil exporting economy like Nigeria. We review some of the leading theories on exchange rate determination in both advanced and developing economies. Those reviewed include the Purchasing Power Parity (PPP), Mint parity (MP), Interest rate Parity (IP), the Fisher Relation (FR), the Asset or Portfolio Balance Approach (PBA), the Elasticities and Absorption approaches (E-APP), and the Monetary and Rational Expectations (RAEXP) approaches.

(a) The Purchasing Power Parity Theory (PPP)

The earliest probable explanation of exchange rate determination was provided by Gustav Cassell in 1918. The explanation which has come to be known as the Purchasing Power Parity Theory (PPP) or law of one price. The PPP is usually expressed in both Absolute and Relative terms. The Absolute version of the PPP asserts that, people will value currencies for what they will buy and that changes in exchange rate reflects changes in relative prices between Countries. It expresses the exchange rate of a country's currency as a ratio between the level of prices in the home country in relation to the foreign country price. On the other hand, the relative version asserts

that the percentage change in the exchange rate from a given base period equals the difference between the percentage change in the foreign price level. Although the PPP has been criticized for its unrealistic assumptions, assumptions, the principle is still admired by many countries, including Nigeria.

(b) The Rational Expectations Theory

Another explanation of exchange rate determination put forward by the Rational expectations proponents, who argue that, the determination of the exchange rate is better expressed in the form of a model under which the equilibrium exchange rate is reached when all economic agents have factored into their consumption and production decisions the relevant available information. To them, the current exchange rate is set by efficient arbitrage between the future (forward) and present (spot) rates.

(c) The Interest Rate Parity Theory

On the other hand, the Interest Rate Parity Theory stipulates that, "the ratio of the forward and spot exchange rates will equal the ratio of foreign and domestic nominal interest rates." For example, if the current foreign interest rate (CFIR) is 15 per cent, while the current domestic interest rate (CDIR) is 10 per cent and the current spot exchange rate (CSEI) is 10 per cent. The predicted current forward exchange rate (CFER) will be calculated thus: -

$$CFER = (1+CFIR/1+CDIR) \times CSER \quad (2.28)$$

$$= (115/1.10) \times 10$$

$$= 10.45 \text{ units of currency}$$

That is, 10.45 Units of foreign currency equals One Unit of the local currency. At Interest parity, the forward rate should make the future value of investments in either Abuja or New York be exactly equal.to the Interest rate obtained in an equilibrium foreign exchange market.

(d) The Forward Parity Theory

The Forward Parity Theory (FPT) is also based on rational expectations and posits that, the markets expectations of the exchange rate price will always be equal to the actual predictions of the underlying theoretical models. In other words, the forward exchange rate (premium) must be equal to the expected future (certain) spot exchange rate. The theory blends the IRPT with the Fisher Relation theory. The theory maintains that, while the exchange rate adjusts instantaneously to the differences in interest rate parity, it adjusts gradually to the PPP, only in the long run.

(e) The Mont Parity Theory

The Mint Parity Theory links the price of currencies to some ounces of gold and allow those currencies to freely convert into gold and vice versa. In that case, an adverse balance of payment position in Country A; will lead to a depreciation in the value of A's currency into gold and to shipment of gold to the other financial canters. The gold is then converted into the currency of Country A and profits made in the transactions. The proceeds made in foreign currency would then be sold, reducing As currency back to the Mint Parity rate of exchange and vice versa.

(f) The Balance of Payment Approach

The other explanations of exchange rate determination which has to do with the process of adjustment in a country's Balance of Payments position includes Alexander's Elasticity and Absorption Approaches, the Monetary approach and the Structuralist explanation to exchange rate determination, which could be applied to the Nigerian, with some modifications. The classical - neoclassical approach (first by Robinson in 1937) to exchange rate determination is linked the Balance of Payments position. The approach, usually referred to as the Elasticity Approach argues that a deficit in the Balance of Payments can be corrected by a devaluation or depreciation of the exchange rate, if the sum of the elasticities of the demand for imports and supply of export is greater than unity, under the Marshall-Lerner condition. That, a lowering of the exchange rate will pro-tanto lower domestic prices and increase import prices. This will have the effect of making home goods cheaper than foreign goods, thus forcing a switch from foreign goods to locally produced goods. Also, because of the low prices of export goods, demand for them will increase forcing production (assuming idle resources) to also increase and so increasing foreign exchange earnings. However, this approach has been found to be of less application to developing countries. For example, it has been empirically confirmed that, using the import demand approaching Nigeria will be difficult because of the high propensity to import (Ozo-Eson, 1984), and that, even though it could increase the inflow of foreign capital, it discourages capital flight and increases the naira value of oil receipts (Falegan, 1978).

According to the monetarist school of thought, any problem in the Balance of Payments is a short-run

phenomenon which can be explained by monetary factors. The monetary approach to the balance of payment improves on the elasticity and absorption approaches, and went forward to argue that, an exchange rate devaluation will by reducing the real value of nominal money balance, through an increase in the domestic prices level, which may only result into a transitory impact with no permanent effect. The approach had come under attack for focusing on monetary factors, and in its defense, proponents had replied that, "the approach did not say that monetary mismanagement is the only cause, nor does it suggest monetary factors are the only solution to the balance of payments problem" (pp 25-6). Although widely applied, the monetary approach has failed to include in its explanation of the balance of payments problem, the presence of structural maladjustments, a key factor in balance of payment difficulties of many developing countries like Nigeria.

The unorthodox structuralist like Villareal, (1980), focuses on this as their approach diagnosed the balance of payments problem by distinguishing the symptoms from the causes and origin of the disequilibria and takes into account, the presence of structural maladjustments in an economy. Under the structuralist approach, the Balance of payments problem is analyzed from a growth perspective and as long- run, rather than short-run phenomena. Some form of model involving the structuralist explanation of an economy, which considers the differences and peculiarities of a country like Nigeria, provides a better starting point for an analysis of the effect of cryptocurrencies on Effect of Cryptocurrency Returns on the Naira – United States Dollar Exchange Rate, Money Demand, and Inflation in Nigeria exchange rate and inflation in Nigeria

2.3 Financial Market Theories

(i) Efficient Market Hypotheses

The Efficient market hypothesis (EMH) as introduced by Malkiel and Fama (1970) is based on the assumption that the stocks are a reflection of all the possible available information in the market which leads us to understand that it is difficult for investors to earn an abnormal return and difficult to 'beat the market. The efficient market hypothesis is divided into three levels, namely the weak, semi-strong and strong forms of markets, which reflects the efficient and transparent transfer of information into the market price at a particular level. The distributed ledger technology is much faster and transparent based technology that can reach and even reflect the data of the market into the asset prices at a faster pace than the current technology. This technology has the capability to reflect information changes on the stocks and currency exchange (mainly cryptocurrency and some banking transactions) quicker than the traditional fiat currencies and exchanges, thus the possibility of making the information transfer much more efficient, timely and transparent. It has to be understood that making this sort of an asset (CCY) an important investment option that can be considered as a basis of stock market news and event reflection is valuable in terms of cost efficiency and transparency not only for the stock exchanges but also the corporates and individuals.

In addition, there is a contrary behavior that was noticed in the investors that were dealing with the cryptocurrency more than the rational behavior assumption under efficient market hypothesis (Coeckelbergh and Reijers, 2016; Garcia, Tessone, Mavrodiev and Perony, 2014). The investors were buying an asset that was valued way below its face value with the expectation that it may give a huge return in the future. Although, this expectation may come true for some investors, but in the later stages, the bitcoin value experienced a sharp decline in its price value by almost fifty percent. Therefore, at a basic level of analysis we could say even with the irrational behavior of the investors, that based on the three variants of the efficiency market hypothesis, the concept of the efficient market hypothesis may need to be further elaborated and examined using the cryptocurrency. The basis of efficient market hypothesis under pure efficiency is the case of random walk and inability to predict the future prices due the random nature of the asset.

The literature, however, has provided a certain degree of similar output in regard to cryptocurrency and its market response and functionality that mainly discusses the market efficiency. Urquhart (2016) uses five different methods to test the possible inefficiency in the bitcoin prices and returns including Ljung-Box for autocorrelation, runs test and Bartel's test for independence of returns, variance ratio test for random walk presence, and BDS test for serial dependence of stock returns. Urquhart (2016) found evidence of bitcoin market being inefficient. However, when the sample was divided into two periods, the latter half indicated to be more efficient, which means that as time duration of Bitcoin business increases, the Bitcoin market may turn to be efficient overall. Nadarajah and Chu (2017) revisited the study conducted by Urquhart (2016) by employing the power test transformation of Bitcoin returns and found a rejection of the efficient market hypothesis/

Using the Hurst exponent, Bariviera (2017) focused on the long-term informational inefficiency of bitcoin markets and reported twofold results, namely before and after 2014. The results showed that, although the Bitcoin market was informationally inefficient, it has been moving towards efficiency after indicating that possible transformations in the market were making it to align with the efficient market hypothesis. Consistent with both Urquhart (2016) and Bariviera (2017), Tiwari, Jana, Das, and Roubaud (2018) also confirmed that, the Bitcoin market was informationally efficient.

Alam (2017) analyzed returns from the Bitcoin and Litecoin using GARCH models and found that. both currencies were not consistent with the weak form of market efficiency hypothesis. Vidal-Tomás and Ibañez (2018) used the AR-CGARCH model, and found that even without the central authority controlling, the Bitcoin market has grown to be more efficient over time although it falls into the semi-strong efficient form of financial market. They also concluded that, the cryptocurrency market which are by nature highly speculative has been creating bubbles due to excessive speculation by the investors and market players. Caporale, Gil-Alana, and Plastun (2018) applied the R/S analysis and the fractional integration methods to identify the long-memory of four cryptocurrencies. They found that the market is inefficient, and that investors can use multiple ways in order to generate abnormal returns and profits. Cheah, Mishra, Parhi, and Zhang (2018) use the cointegrated vector autoregression (VAR) framework and found that Bitcoin market is not efficient. On similar lines of studying the long memory of Bitcoin through volatility and potential presence of structural breaks, Bouri, Gil-Alana, Gupta, and Roubaud (2018) found that shocks had a long-memory effects that are found in the absolute and squared returns measure for the volatility. They supported the argument of presence of inefficiencies in the Bitcoin market based on the conclusion of absence of mean reversion and long memory. Kristoufek (2018) studied the Bitcoin efficiency using the US and Chinese currencies and found that both markets portray an inefficient basis with certain glimpses of efficiencies in small portions based on an efficiency index created by Kristoufek and Vosvrda (2013).

On a more comprehensive approach to a study on cryptocurrency returns was undertaken by Wei (2018), who investigated four hundred and fifty (450) cryptocurrencies using the Hurst exponent and found that the cryptocurrency with high market liquidity had low return predictability and that the cryptocurrencies failed to influence market efficiency especially the new cryptocurrencies. expanding on earlier idea of herding under diversification concept, Bouri, Gupta, and Roubaud (2018) also examined the herding effect based on different methodologies suggesting an influence on market efficiency and risk management that can be induced from the outcome. Using the static model, they did not find any significant herding effect; however, applying the rolling-window effect due to the inappropriateness of static model suggested a significant time-varying herding effect. A third measurement of logistic regression suggests the existence of herding with an increase in uncertainty.

In order to give a small preview on the potential of distributed ledger technology (DLT) it is so that, the efficient market hypothesis and the distributed ledger technology could be combined and seen in a tandem. As distributed ledger seems to be a better alternative to the current news and event reflection mechanism on the market prices of different assets and investment alternatives due to its nature of being more transparent as its availability on the public spectrum. This concept of efficient market hypothesis leads us to other possible outcomes and basis that it assumes, it is the market efficiency establishment through the invisible hand of competitive markets, achieving efficiency and equilibrium in the market, production efficiency, the exchange efficiency, among others. However, the researchers and investors should consider the highly volatile nature of the current cryptocurrency, although the distributed ledger may be a better technological basis of application with a sound foundation in other investment areas. As mentioned by Zalan and Toufaily (2017), the distributed ledger has been internationally accepted by various organizations as a trusted resource in the banking sector. Hence, the same can be applied in the stock market and the foreign exchange market as well. This may encourages testing the validity and the reliability of distributed ledger application in the financial sector (Fanning & Centers, 2016). Understanding the cryptocurrency s market efficiency from a COVID-19 perspective,

Mnif, Jarboui, and Mouakhar (2020) studied how the cryptocurrency market has performed using a multifractal analysis considering the cryptocurrency s have an almost analogous nature. This study had a more direct approach with respect to the efficient market hypothesis theory in terms of analysis and output as market efficiency was the primary objective with an underlying approach of the herding effect under the COVID-19 conditions for five cryptocurrency s (BTC, ETH, XRP, Litecoin and Binance). The study applied three methodologies – the "Multifractal detrended fluctuation analysis", generalized Hurst exponent and magnitude of long-memory – to cover the different time series (mainly long-term) characteristics that has the potential to find possible implicit information and trends. The five cryptocurrencies studied in the paper were found to be

influenced by herd behavior as also found in similar studies for the period up until May 2020. However, the efficiency of certain cryptocurrencies differs from one to the other, as Bitcoin were found to be less efficient during COVID-19 as compared to Ethereum whilst the former showed better efficiency pre-COVID-19 conditions. This possibly could be due to the enormous market share of BTC and trade volume that it possesses in the cryptocurrency market (Coinmarketcap, 2020). Moreover, the use of traditionally long-term methodology to identify a during (post) COVID-19 efficiency over a span of five months data of volatile cryptocurrency's may not be an adequate and significant result to base decisions upon, therefore, more time-series relevant data-based output should be pursued.

It can be observed that the outcome of the studies in this area of finance is not completely conclusive to be significantly applied and needs more research, it can be seen that the efficiency of cryptocurrency is enhanced with the maturity of their markets. The available research shows that the cryptocurrency market (especially the bitcoin) is acting more like an alternative investment asset and its efficiency tests produce mixed results based on different methods and time periods. However, more evidence is required in order to reach to a more satisfactory outcome with use of different efficient market hypothesis testing models that can assist in determining the efficiency for not only bitcoins but also cryptocurrency s in general as the expansion of the cryptocurrency is expected. The limited time-series based evaluation that may need more data points to provide a more applicable outcome. As described above in relation to the characteristics of distributed ledger technology and cryptocurrency, it would be a winning bet to adapt technology by the institutions (such as stock exchanges, banks, other financial institutions, etc.) with sufficient regulation.

(ii) Adaptive Market Hypothesis

Adaptive market hypothesis (AMH) was developed by Lo (2004), which is an evolutionary version of the efficient market hypothesis. The basic concept of efficient market hypothesis as mentioned earlier is about the basic efficiency of markets based on various events and no party involved in the transaction can make an abnormal return with all the information available to the market. However, Lo (2004) provided a reconciliated theory that combines the economic aspect as well as the behavioral aspect of the decision makers. This hypothesis also relates to the risk-return model as it assumes that the risk-return relation may not always remain in tandem and certain models and strategies may work well in certain markets than others with possibility of arbitrage. Hence, with advancement in finance and related aspects, it has to be expected that the advent of DLT and cryptocurrency may lead to a certain arbitraging in the cryptocurrency market for the investors with advanced skills. However, like the expectation of the increase in market efficiency in efficient market hypothesis, it can be expected that Adaptive market hypothesis will ensure that markets and stakeholders will eventually adapt and overcome the barriers in the cryptocurrency market that may hinder the application of financial and investment theories.

A study by Khuntia and Pattanayak (2018) is one of the limited publications that have specifically examined AMH in relation to Bitcoin (BTC). They applied the Dominguez-Lobato consistent test and generalized spectral test in order to capture the time-varying linear and non-linear dependence in the Bitcoin returns. Similar to the outcome of studies in efficient market hypothesis section (Bariviera, 2017; Tiwari et al., 2018 and Urquhart, 2016), they found that overtime the efficiency of the bitcoin improves that also validates the different implications of the Adaptive market hypothesis. With little reference to the Adaptive market hypothesis, Koutmos (2018a) looked at the microstructure of the Bitcoin market in relation to the liquidity uncertainty and the aspects that can describe this behavior over time. Using the ARMA-GARCH model and the Markov regime-switching model, Koutmos (2018a) found changes in different regime based on uncertainty. These changes create a difficulty in determining the factors affecting the adaptation of liquidity uncertainty through bitcoin prices and other factors (volume, size, fees, volatility, hash rate, unique bitcoin addresses). Which creates a need for revisiting for these determinants sometime in the future with more stable data set. In support of applying Adaptive market hypothesis models in order to study cryptocurrency market improvement, Köchling, Müller, and Posch (2018) studied the possibility of efficiency improvement in bitcoin market and find that bitcoin market had turned price efficient generally. This also supports the efficient market hypothesis and also encourages researchers to study the same effect on other cryptocurrencies.

Khursheed, Naeem, Ahmed and Mustafa (2020) study the time varying market efficiency with relation to Adaptive market hypothesis. The paper uses three different methods including generalized spectral, automatic portmanteau and Dominguez-Lobato tests. Four cryptocurrencies were studied for a period of five years. Certain cryptocurrencies (such as Bitcoin, Litecoin, Monaro) have a comparatively longer efficiency period than Steller (which has a more inefficient run). In line with similar research, this study suggests that the cryptocurrency price variations are impacted by varying market periods. The paper also suggests the use of Adaptive market

hypothesis or a better forecast of market efficiency due to the changes in market conditions. This paper has a more elaborate approach towards Adaptive market hypothesis and market efficiency. However, the paper may need to support the inclusion of the mentioned cryptocurrencies as there are other cryptocurrencies that are traded more with a higher market value (such as Ethereum, XRP, etc.). Therefore, the possible benefit to the stakeholder based on the outcome of the study may be limited as the market influence of these cryptocurrency cryptocurrency's small (Coinmarketcap.com, 2020). However, the contribution in terms of analysis could be further applied to other studies that can supplement the method and results.

Abdelrhim et al. (2020) study the possible opportunities to invest during the COVID-19 situation by comparing cryptocurrency's (BTC, ETH and Tether) and metals (gold, silver and copper). The possible combination of different investment assets may provide an adaptive market approach and risk-distribution, although the paper through its general literature provides some attention on certain efficient market hypothesis papers. While the paper requires deeper literature analysis and theory build-up in relation to investment and finance, it provides a different kind of outlook on the pandemic and its relationship with the investment opportunities in the market. The basic data structure was based on the COVID-19 data of deaths (daily and total) and positive cases (daily and total) of more than 200 countries and the returns on the different investment alternatives over a limited time period of three months (from end of March 2020 during the pandemic). The results show that cryptocurrency s had better return on investment during the above period with Ethereum providing returns of more than seventy percent while silver and Bitcoin gave around 40% return. Other metals (copper and gold) and cryptocurrency (Tether) had the least return on investment. However, the paper analysis may need further robustness tests in order to provide additional support to the results for its general applicability. Since the data set was limited to the three months during the pandemic, an increased data set in addition to a pre and post COVID-19 would provide a better understanding and comparison of returns. Additionally, it can also provide insights into the changes of returns in the two durations and show how the pandemic among other potential factors may have influenced different investment opportunities and basket of assets.

It is important to understand the standing of cryptocurrency under Adaptive market hypothesis as it can assist the stakeholders in further solidifying the position of cryptocurrency as a long-term asset that can adapt to market changes or if it is jus a bubble that shall fade away by time due to its speculative nature and rigidness to regulations and other investment and market functionalities. As markets and behavior of people does not solely depend on price of the asset itself, this theory encourages the analysis of other factors that can have a significant influence on an investor's choice and decision of investment. Adaptive market hypothesis is a significant theory in this area of research mainly for the fact that the high volatile nature of the cryptocurrency's involves the decision and influence of human interaction and speculation that has multiple parameters and objectives. It provides significant influence of human thinking and behavior that other traditional finance theories may not incorporate completely. The outcome of COVID-19 studies in relation to investment and diversification via multiple asset options needs further research and analysis. This is mainly due to the short period of time-series data that has been used and the lack of sufficient analysis that can provide adequate support for the results to be taken into significant consideration.

2.4 Research Gap

In the review of the literature on the effect of volatility in cryptocurrency returns and the determinants of changes in the exchange rate, money supply and inflation function, we found complete dearth of studies directly on the topic. However, there are studies that dealt with some aspects of the topic. We organize the literature review in terms of studies on cryptocurrency and exchange rate, cryptocurrency and money supply and cryptocurrency and inflation. Therefore, this study contributes to the literature by analyzing the effects of cryptocurrencies on macroeconomic indicators in Nigeria using the spillover index advanced by Diebold and Yilmaz (2012). This index is hinged on the framework of the VAR(p) model. Therefore, the directional spillovers, net spillovers, and total spillovers from cryptocurrencies on macroeconomic variables such as exchange rate, inflation, and money demand in Nigeria are examined. Therefore, this study would provide insights into the formulation of appropriate monetary policies to attain the primary goal of price stability and economic growth.

3.0 Methodology

This study employs the causal research design, which is also called the explanatory research design. According to Kothari (2004), causal research design is a type of research design that involves the assessment of the cause-and-effect relationships among variables. It is based on the principle that if a statistically significant

relationship exists between two variables, then it is possible to predict the dependent variable using the information available on the independent variables. Furthermore, Kothari (2004) observed that the causal research design is used to investigate the effect of one variable on another. In this case, the effect of volatility in selected cryptocurrencies of Bitcoin, Ethereum, and Dash Coin on exchange rate, money demand and inflation rate in Nigeria during the period 2015to 2021.

3.1 Type and Sources of Data

The data for the study were sourced mainly from the Central Bank of Nigeria Statistical Bulletin and complemented by downloads from websites of Central Bank of Nigeria, Kneoma.com, cryptocurrency reporting websites, and the World Development Indicator. The dependent variables include official exchange rate of naira to USD (EXR_t), year-on-year inflation rate in Nigeria (INF_t) and money demand ($M^d{}_t$)proxied by $M2$. Furthermore, the explanatory variables used include three different and major cryptocurrencies, namely, Bitcoin ($BitC$), Ethereum($ETHr$), and Dash coin ($DasC$). Other controlled variables are economic activity (GDP) and WTI Oil price ($OilP$). The data for exchange rate of naira per US dollar, year-on-year inflation rate, and money demand (M2) are obtained from the website of the Central Bank of Naira. Data for Oil price is generated from the Federal Reserve Economic Data website while per capita GDP data is collected on yearly frequency. However, to suit the focus of this study, the per capita GDP data is converted to monthly frequency via quadratic interpolation technique using Eview 10. This approach is demonstrated in Balcilar et al. (2019). `

3.2 Justification for the Choice of Modelling Techniques

In this study, the concern is to examine the effects of cryptocurrency returns, and volatility on the Naira United States dollar exchange rate, money demand, and inflation in Nigeria. To achieve this objective, we use different methodologies that can capture the three main focus of this study.

First, to capture the effects of cryptocurrency returns and volatility from the bitcoins, Ethereum, and Dash coins on exchange rate, money demand, and inflation in Nigeria, we apply the novel GARCH-MIDAS and the dynamic autoregressive distributed lag (ARDL) models to simulate an estimation technique recently advanced by Jordan and Philips (2018). This model is not only capable of addressing the problem of complication in statistical inference of in-sample parameters as found in the standard ARDL model but also addresses the out-of-sample effects of counterfactual shocks in explanatory variables at a given period.

Second, to examine the effect of cryptocurrency returns and volatility on the Naira United States dollar exchange rate, the demand for money and inflation in Nigeria, we applied the GARCH-MIDAS regression. This model is considered suitable because it accommodates mixed frequencies series with unequal periods. Basically, in examining returns volatility, daily frequency series are better as it processes a robust result. To avoid losing some information in the course of converting a high frequency to a low frequency and vice versa, the GARCH-MIDAS model is adopted but complemented with and dynamic autoregressive distributive lag (ARDL) model. Moreover, it is common to find ARCH effect in the high frequency series. This can hamper the outcome of the analysis. To circumvent this, MIDAS regression approach is applied which generate volatility from the GARCH 1,1. where some variables explored are in their daily frequencies and others, particularly the macroeconomic variables are in low frequencies or monthly frequencies for the period under review.

Third, for checking the robustness of the analysis, we capture the effect of cryptocurrency returns and volatility on exchange rate, money demand, and inflation in Nigeria through the analysis of the Diebold-Yilmaz spillover index developed by Diebold and Yilmaz (2012). This approach measures the contribution of each of the types of cryptocurrencies, say bit coins, Ethereum, and dash coins on exchange rate, money demand, and inflation in Nigeria. By this model, the total contribution, direction of the contribution, and net-effect of the contribution are examined.

3.3 Specification of Empirical Models

Given the increasing trade in cryptocurrencies and its recognition by the global economy as a medium of exchange and means of settlement of debts, even though the discouragement of such trade by Central Bank of Nigeria, there is no doubt that such trade may play significant effects on core macroeconomic variables in Nigeria. Therefore, the broad objective of this study is to examine the effects of cryptocurrency returns and volatility on the naira – United States dollar exchange rate, money supply, and inflation in Nigeria. To achieve

this, an empirical model is constructed using three major cryptocurrencies.8 Based on this, the empirical models are specified as follows:

$$\text{EXR}_t = f(BitC_t, ETHr_t, \text{DasC}_t, GDP_t, OilP_t) \quad (3.1)$$

$$M^d{}_t = f(BitC_t, ETHr_t, \text{DasC}_t, GDP_t, OilP_t) \quad (3.2)$$

$$\text{I}NF_t = f(BitC_t, ETHr_t, \text{DasC}_t, GDP_t, OilP_t) \quad (3.3)$$

where the dependent variables include; exchange rate of naira to USD (EXR_t) inflation rate in Nigeria (INF_t) and money demand ($M^d{}_t$). As earlier said, the cryptocurrencies which are the main explanatory variables of interest, are based on five different types, namely, Bitcoin ($BitC_t$), Ethereum($ETHr_t$), and Dash coin ($DasC_t$). Other controlled variables are economic activity (GDP_t) and Oil price ($OilP_t$).The 't' denotes time period, August 2015 to December 2021, which involves monthly data.

Given the functional relationships in equations 3.1 –3.3, the variables are transformed into their natural logarithms to possibly remove the problem of heteroscedasticity and any non-linear functional form. Therefore, the log-linear specification of the structural model are provided in equations 3.5 – 3.6 below as follows: -

$$\ln \text{EXR}_t = \alpha_0 + \alpha_1 \ln B\,itC_t + \alpha_2 \ln E\,THr_t + \alpha_3 \ln D\,asC_t + \alpha_4 \ln GDP_t + \beta_5 \ln O\,ilP_t + \varepsilon_t \quad (3.4)$$

$$\ln M^d{}_t = \delta_0 + \delta_1 \ln B\,itC_t + \delta_2 \ln E\,THr_t + \delta_3 \ln D\,asC_t + \delta_4 \ln GDP_t + \beta_5 \ln O\,ilP_t + \varepsilon_t \quad (3.5)$$

$$INF_t = \alpha_0 + \alpha_1 \ln B\,itC_t + \alpha_2 \ln E\,THr_t + \alpha_3 \ln D\,asC_t + \alpha_4 \ln GDP_t + \ln O\,ilP_t + \varepsilon_t \quad (3.6)$$

where:-

ln denotes the natural logarithms of the variables to help remove non-linear functional form and to stabilize the variance,

ε_t is the residual or error term which is possibly assumed to follow a stochastic Gaussian process with zero-mean and variance σ^2, $\varepsilon_t \sim iid(0, \sigma^2)$.

3.4 The Structural Equations for the GARCH-MIDAS Model

The structural specification of these relationships is as follows; -

Given the above equations 3.4 – 3.6, we shall be using the MIDAS regression to analyze the data and according to Wikipedia,

"a MIDAS regression is a direct forecasting tool which can relate future low-frequency data with current and lagged high-frequency indicators, and yield different forecasting models for each forecast horizon"

In addition, MIDAS regression also has the ability to "flexibly deal with data sampled at different frequencies and provide a direct forecast of the low-frequency variable" as it "incorporates each individual high-frequency data in the regression, thus solving the problems of losing potentially useful information and including misspecification". In its simplest form, the MIDAS regression model is given in equation (3.7) below as follows:

$$y_t = \beta_0 + \beta_1 B(L^{\frac{1}{m}}; \theta x_t^{(m)}) + \varepsilon_t^{(m)} \quad (3.7)$$

where:

y_t is the dependent variable, x_t is the regressor, m denotes the frequency – for instance where is the monthly data or low frequency, and

X_t is daily data or high frequency,ε= epsilon is the disturbance term.,

$B(L^{\frac{1}{m}})\theta$ = lag.

[8]These three cryptocurrencies are the major ones as they constitute over 90% of the entire cryptocurrency market.

A simple regression example has the independent variable appearing at a higher frequency than the dependent variable: where y_t is the dependent variable, x_t is the regressor, m denotes the frequency – for instance, if $y_t$is redistribution, for instance, the beta function or the Almon Lag. For example. The regression models can be viewed in some cases as substitutes for the Kalman filter when applied in the context of mixed frequency data. The MIDAS regressions involve a (reduced form) single equation and as such, are fairly efficient and less prone to specification errors as since, the approximation errors tend to be small. The dependent variables are the selected macroeconomic variables in the Nigerian economy, namely the Naira to one United States dollar exchange rate, the demand for money and the rate of inflation in Nigeria, while the explanatory variables are the Bitcoin, Ethereum and Dash coin cryptocurrency returns and volatility. Now due to the differences in data frequencies, the study used the Generalized autoregressive conditional heteroskedasticity (GARCH[9]) process that was developed by Robert F. Engle (1982), along the Mixed data frequency Sampling (MIDAS) to form GARCH-MIDAS. The GARCH-MIDAS model as used by Nelson (1991) was found to be efficient in capturing the asymmetric effects of returns and volatility as well as in ensuring that the variances are positive.

3.5 The GARCH-MIDAS Model

In order to understand the GARCH-MIDAS model, we begin form the general GARCH (p, q) process, which focuses on estimating both the mean and variance equations to identify the short and long run components. We shall begin by presenting the general conditional variance equation of the general GARCH model as follows:-

$$log(\mu_t^2) = \alpha_0 + \psi_1 \left[\frac{\varepsilon_{t-1}}{\mu_{t-1}}\right] + \psi_2 \, log \quad (\mu_{t-1}^2)\, \gamma \frac{\varepsilon_{t-1}}{\mu_{t-1}} \tag{3.8}$$

where :--

$\mu_t^2$is the conditional variance of cryptocurrency returns and volatility for each of Bitcoin, Ethereum, and Dash coin series for the study period August 2015 to December 2021,$\alpha_0 = conditionalvariance$

$\left[\frac{\varepsilon_{t-1}}{\mu_{t-1}}\right]$is the ARCH term showing the magnitude of past shocks to volatility in each of the cryptocurrency and the degree of volatility clustering.

$(\mu_{t-1}^2)$is the GARCH term,

$\left[\frac{\varepsilon_{t-1}}{\mu_{t-1}}\right]$ is the ARCH component showing leverage effect,

α0 is the constant, and ψ1 is the coefficient of asymmetry, ψ2 is the coefficient of persistence, while ϒ is the leverage coefficient showing the leverage effect. where negative returns (shocks) are expected to produce higher volatility than positive returns of the same magnitude which further confirms the role of asymmetry and μ_t is the error term that is uncorrelated with its past values.

Given the above equations (3.1 – 3.8), the dependent variables for the analysis would be selected macroeconomic variables in the Nigerian economy, namely the Naira Dollar Exchange rate, money demand and inflation, while the independent or explanatory variables are the Bitcoin, Ethereum, Dash coin cryptocurrency returns and volatility

In order to begin the GARCH-MIDAS process of modeling cryptocurrency adopt a similar procedure used by Engle et. Al (2013), in which he broke down the conditional variance, which was multiplicative into and short run and long run components The short run took care of the high frequency while the long run took care of the low frequency component of the model. The long run component is the stated as a function of explanatory variables. This would allow us to estimate both the financial and macroeconomic determinants of the cryptocurrency returns and volatilities. Let us now begin by defining our variables for the model. First, let us begin by first defining the daily cryptocurrency returns as T_{it} which is given in equation (3.9) below: -

$$T_{it} = 100 * (lnP_{i,t} - lnP_{i,t-1)}) \tag{3.9}$$

where:-

[9]We would like to note however, that although the GARCH suffers from structural breaks, dividing the data into sub-samples or regimes, was found to have helped in switching between regimes and to have allowed return volatilities in the short-term component change among the two regimes.

Pit= Cryptocurrency price at given period ,t, with$t = 1 \ldots\ldots, N$t.

T denotes the monthly frequency and$i = 1 \ldots\ldots, N$t. represent the number of days within month, t. and let us assume that each of the conditional mean of the Bitcoin, Ethereum and Dash Coins cryptocurrency returns and volatility and is given as follows; -

$$T_{it} = \mu + \varepsilon_{i,t} \quad (3.10)$$

with the error term defined as:

$$\varepsilon_{i,t} = \sqrt{\text{hit}T_{it}Z_{it}} \quad \textbf{(3.11)}$$

where, we hit as representing the short run, T_{it} is the long run component of the conditional variance and Z_{it} are the innovations or shocks to the model., which are assumed to be i.i.d. with a mean of zero and constant variance of one. The short run component, hit changes at the daily frequency following a unite variance GARCH (1, 1) process, which is explained below as:

The Short run component,

$$\text{hit} = (1- \alpha- \beta) +\alpha((Ɛ2i,- 1\ t)/Tt\ ) + \beta\text{hit -1 t} \quad (3.12)$$

where, $\alpha > 0$, $\beta \geq 0$, and $\alpha + \beta < 1$

Th Long run component, T_{it}, varies at the monthly frequency. This is also given by the tau formula for calculating long run component under the GARCH-MIDAS is presented below as follows::

$$\log T_{it} = m_t + \theta\sum\varphi\ (\omega_1, \omega_2)\ X_{t-kj} \quad (3.13)$$

where-

X_t are the explanatory variables or the Naira United States dollar exchange rate, demand for money, inflation, oil price, and the gross domestic product, $_{mt}$ is the constant term or intercept, and the $\varphi,(\omega_1, \omega_2)$ is the weighting scheme, which in this case, we shall use as weights or φ ,θ is beta, and formula given as :

$$k\ (\omega_1, \omega_2) = (k/(K+1))\ \omega_{1-1}.(1-k/(K+1)\ ))\ \omega_{2-\ 1} +\ (1-K/(?(k+1))))\omega_{2-1}$$
$$(1-J/\ (k+1))\ \omega_{2-1} \quad (3.14)$$

Note that, the weights will be by multiplying the beta by product of the weights thus:-

$$\eth k(\ \omega_1, \omega_2) >= 0,\ k = 1, ,\ \text{ and K sums up to one.}$$

when empirically applying the model to Nigeria, we will be impose restriction that w1 = 1, which implies that the weights are monotonically declining.

Based on the above and adopting the procedure by Conrad and Loch (2015, 2018), we can employ three MIDAS lag years, which would imply that for the monthly frequency, we now let K=36 for the monthly explanatory variables. With this, our empirical results will show that the choice was appropriate in the sense that the estimated weights would gradually approach zero before 36 months or lag 36/. As in Engel et. al. (2013) and Conrad et al. (2018), we can now apply the GARCH-MIDAS model (equations 3.9 – 3.14) using quasi-maximum likelihood and from there proceed to construct the heteroscedasticity and autocorrelation consistent (HAC) standard errors We can then use the conditional mean and conditional variances estimated from the GARCH-MIDAS model and proceed to interpret the values of their coefficients and other statistical values obtained for both apriori expectations and implications for future policy..

3.6 Method of Data Analysis

The study will employ a variant of the MIDAS- Model to estimate the equations given the mix of both low and high frequency data and volatile nature of most cryptocurrencies. In particular, we shall follow after Engel et. al. (2013), to use the GARCH-MIDAS model which can be used to identify the different components of short` and long run positions, when using low and high frequency data. According to Conrad, Custovic, and Ghysels (2018), the GARCH-MIDAS model is good at analyzing both high and low frequency data, as it was modelled to identify both the short-term of a GARCH (1,1) process as well as the long-term component. The author applied the GARCH- MIDAS model to establish the short and long run drivers of volatility in bitcoin

prices following Panagiotis, (2019). They also found that, the parameters estimated by the GARCH-MIDAS method were more efficient than those from ordinary least squares or the GARCH process alone.

The study therefore uses the GARCH10-Mixed data frequency Sampling (MIDAS) to model volatility in the cryptocurrency returns, while noting some of the shortcomings of GARCH. The GARCH-MIDAS model as used by Nelson (1991) was found to have captured asymmetric effects of volatility returns as it ensured that the variances were positive. The Conditional variance of the model was expressed as a function of the explanatory variables, which would be used to investigate the effect of volatility in cryptocurrency returns of Bitcoin, Ethereum, and Dash Coin on the Naira-Dollar exchange rate, money demand and inflation in Nigeria during the period 2015 to 2021. In the model therefore, we used daily cryptocurrency volatility returns of the Bitcoin, Ethereum, Dash Coin, Doge coin and Litecoin (high frequency) and the monthly data (low frequency) on the Naira Dollar Exchange, Money demand and Inflation as explanatory variables. In order to estimate volatility in cryptocurrency returns of the Bitcoin, Ethereum, and Dash coin.

3.7 The MIDAS Regression

The Mixed Data Sampling regression analysis module in the EViews software can be described as an estimation technique that allows for data that has been sampled at different frequencies to be used in the same regression. The MIDAS procedure used in this study is briefly described. In order to use the MIDAS regression method of analyzing mixed data, we first obtained the data on the cryptocurrencies, especially the bitcoin, Ethereum, dash coin, Doge coin and Litecoin from the internet websites of Yahoo finance but complemented them with those from the Fred Database. Then, we obtained data on the selected macroeconomic variables of money demand/supply, naira-dollar exchange rate and inflation mainly from the Central Bank of Nigeria (CBN) website but complimented with data from National Bureau of Statistics. The logarithmic transformation of the data was carried out and the data was then imported into the EViews work file, where we created a work file for each of the daily and monthly files.

The EViews software provides a good flatform for the analysis of Mixed frequency Data sampling (MIDAS), since we were confronted with dealing with both daily and monthly data set. Next, we carried out the MIDAS regression of each of the selected independent cryptocurrency variables of the Bitcoin, Ethereum, and Dash coins on the demand for money, the Naira- United States Dollar exchange rate and inflation, for the period covering August 2015 to December 2021, to establish the effects of volatility in returns from these cryptocurrencies on the selected macroeconomic variables in Nigeria. The analysis and interpretation of results as well as the discussion of their implications for monetary policy in a developing and emerging economy like Nigeria, was undertaken.

3.8 Diebold-Yilmaz Spillover Index

To examine the effects of return and volatility of cryptocurrencies on exchange rate, inflation, and money demand in Nigeria, the Diebold -Yilmaz (DY) spillover index developed by Diebold and Yilmaz (2012; 2014) is explored. This index is computed within the framework of the Generalized Vector Autoregressive (VAR) by Koop et al. (1996) and Pesaran and Shin (1998). Furthermore, the DY index uses the forecast error variance decomposition, which is considered invariant to the ordering of variables as demonstrated by Balcilar & Usman, (2021). Thus, following a study by Diebold and Yilmaz (2009) and its extension by Diebold and Yilmaz (2012; 2021), we consider the general form of VAR(p) with covariance stationary N variables.

$$z_t = a_0 + \sum_{j=1}^{p1} a_j y_{t-j} + \varepsilon_t \tag{3.15}$$

where N represents the number of variables, $z_t$is $(N \times 1)$ a vector of the dependent variables, $a_i$denotes the $N \times N$matrix of the autoregressive coefficients, and ε_t is a zero mean white noise process with covariance matrix Σ, $\varepsilon_t \sim iid(0, \Sigma)$. Equation (3.15) can be written in terms of a moving average as follows:

$$= \sum_{i=0}^{\infty} Y_i \varepsilon_{t-i} \tag{3.16}$$

where the $k \times k$ remains coefficient matrices, Y_i is presumed to follow the recursion $Y_i = a_1 Y_{j-1} + a_2 Y_{j-2} + \cdots + a_p Y_{j-p}.Y_0$ is said to be the $N \times N$ identity matrix, where $a_i = 0$for $i < 0$. Following the

[10]We would like to note however, that although the GARCH suffers from structural breaks, dividing the data into sub-samples or regimes, was found to have helped in switching between regimes and to have allowed return volatilities in the short-term component change among the two regimes.

moving average for generalized forecast error variance decomposition as specified in Equation (3.15), three (3) main dimensions of the return and volatility spillovers are computed, namely; directional spillover, total spillover, and net spillovers. Furthermore, for this kind of spillover, the "own variance shares" are measured as the fractions of the H-step-head error variances to forecasting $z_i$for $i = 1,2,\dots,N$ while for "cross variance shares" are measured as the fractions of the H-step-ahead error variance in forecast z_{it}possibly resulting from the shocks to z_{it}, for $i = 1,2,\dots,N$, such that $i \neq j$. To this extent, Diebold and Yilmaz (2012) suggest that the H-step-ahead generalized forecast error variance decomposition developed by Pesaran and Shin (1998) can be followed.

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1}\sum_{h=1}^{H-1}\left(e_i' Y_h \Sigma e_j\right)^2}{\sum_{h=1}^{H-1}(e_i' Y_h \Sigma Y_h' e_i)\,,} (3.17)$$

where Σ is the variance matrix of the residual vector ε_t,σ_{jj} represents the standard deviation of residual terms for j-th equation, $e_i$denotes the selection vector where 1 stands for the i-th element, and 0 otherwise. The sum of the own variance share and cross variance share contributions are of course not equal to unity under the generalized decomposition, that is $\sum_{j=1}^{N}\Theta_{ij}^{g}(H) \neq 1$. Therefore, as suggested by Diebold and Yilmaz (2012) by normalizing each entry of the variance decomposition matrix by the sum of the row provide the following outcomes:

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N}\theta_{ij}^{g}(H)} \quad (3.18)$$

where $\sum_{j=1}^{N}\tilde{\theta}_{ij}^{g}(H) = 1$and $\sum_{i,j=1}^{K}\tilde{\theta}_{ij}^{g}(H) = N$. The total return and volatility spillover index can therefore be computed as follows:

$$S_T^{g}(H) = \frac{\sum_{i,j=1,i\neq j}^{N}\tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N}\tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{i,j=1,i\neq j}^{n}\tilde{\theta}_{ij}^{g}(H)}{N} \times 100 \quad (3.19)$$

where $S_T^{g}(H)$ represents the return and volatility spillover. This index is perhaps applied to show the average effect of the spillover of cryptocurrencies from the shocks across the variables of interest such as exchange rate, inflation, and money demand to the total forecast error variance decomposition.

As earlier mentioned, the focus on three different return and volatility spillovers of cryptocurrencies to exchange rate, inflation, and money demand in Nigeria. To compute the directional spillover, attention is given to two main dimensions: the directional spillovers received by variable i from other variables j, and also the directional spillovers transmitted by variable i to other variables j. Specifically, the directional spillovers received by variable i from other variables j can be computed as follows:

$$DS_{i\leftarrow j}^{g}(H) = \frac{\sum_{j=1,j\neq i}^{n}\tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{n}\tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{j=1,j\neq i}^{n}\tilde{\theta}_{ij}^{g}(H)}{N} \times 100 \quad (3.20)$$

Again, the directional spillovers transmitted by variable i to other variables j can be computed as follows:

$$DS_{i\rightarrow j}^{g}(H) = \frac{\sum_{j=1,j\neq i}^{n}\tilde{\theta}_{ji}^{g}(H)}{\sum_{i,j=1}^{n}\tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{j=1,j\neq i}^{n}\tilde{\theta}_{ji}^{g}(H)}{N} \times 100 \quad (3.21)$$

Furthermore, the net spillovers from variable i to all other variables $j$cane computed by subtracting equation (3.20) from equation (3.21) as provided as follows:

$$NS_i^{g}(H) = DS_{i\rightarrow j}^{g}(H) - DS_{i\leftarrow j}^{g}(H) \quad (3.22)$$

Here, the net spillover (NS_i^{g}) is calculated from the spillovers emitted to and the spillovers received from other variables. In other words, net spillovers are expressed as the difference between the gross shocks transmitted to and shocks received from all other variables in the system. It is important to note that, the difference between this measurement with directional spillovers as given in equations 3.20 and 3.21, is the addition of the net spillover, which is estimated by finding the difference between shocks to others and shocks

received from others, by a market. In general, if the value or spillover is positive, it is called a net transmitter and if it is negative, it is a net receiver.

4.0 Analysis and Discussion of the Results

In this chapter, we present and analyze the results of the analysis of data on the effect of cryptocurrency returns and volatility on the Naira- United States dollar exchange rate, money demand and inflation in Nigeria during the period August 2015 to December 2021 using daily and monthly. The aim is to establish the link between changes in cryptocurrency returns and volatility, especially those of the Bitcoin, Ethereum and Dash coin on selected macroeconomic variables such as the Naira-United States dollar exchange rate, money demand and inflation in Nigeria during the review period.

The focus of this chapter is to present the results of the GARCH-MIDAS and Diebold-Yilmaz spillovers analyses and discussed each of these results against our research objectives and hypotheses earlier identified in the study. The hypotheses were stated in their Null form and were tested at the 5% level of significance, was aimed at either confirming or rejecting the following:

> H01: Cryptocurrency returns and volatility, particularly those of the Bitcoin, Ethereum and Dash coin have no significant effect on the Nigerian Naira – United States dollar exchange rate
>
> H02: Bitcoin, Ethereum and Dash Coin Cryptocurrency return and volatility have significant effect on the efficacy of the monetary policy goals and outcomes of the Central Bank of Nigeria.

Table 4.1 presents the descriptive statistics of the variables used for this study. Panel A reports the variables in their log levels while panel B reports the variables at first difference. From the Table in panel A, it is shown that the mean scores of economic activity and money demand are higher than the mean scores of the rest variables. Among the three cryptocurrencies used, the mean score of bitcoin is higher, suggesting that bitcoins have a dominance in Nigeria. For Panel B, the mean scores of the variables are smaller. This is due to the fact that the series are in their first difference. Moreover, the standard deviation values of the series suggest that the series have less volatility in both log levels and first differences. The values of the skewness in Panel A show that apart from inflation and money demand, the rest of the variables have a negative skewness with the values higher than normal values in most of the variables. However, in Panel B, it is shown that the skewness for all the variables is positive, suggesting that all the variables are positively skewed. For the case of kurtosis, it is clear that for both log levels and first differences, the variables have a positive ketosis with some of the variables having an excess kurtosis. Consequently, the Jarque-Bera statistics of normal distribution cannot be accepted for some of the variables.

For example, in Panel A, the J-B statistics for exchange rate, bitcoin, Ethereum, gross domestic price and oil prices fail to be accepted. This failure is more conspicuous in Panel B where bitcoin is the only variables that seems to be normally distributed. Furthermore, Panels C and D reveal the descriptive statistics of variables in daily frequencies (i.e. log BITC, log ETHR, and log DASH). From the panels, it is clear that Bitcoins have the largest mean scores among these variables.

Pertaining to their standard deviation which is the indicator of volatility, it is clear that the log of Ethereum had the highest, which indicates that it is more volatile. Moreover, the skewness and kurtosis show that the variables are positively skewed with positive kurtosis in their first differences. Although the values of kurtosis are extremely large, suggesting that the variables have excess kurtosis. Also, in their log-difference, the skewness of log-Bitcoin and log Ethereum is negative, suggesting that these variables are skewed to the left.

Panels C and D reveal the descriptive statistics of variables in daily frequencies (i.e. log BITC or Bitcoin, log ETHR or Ethereum, and log DASH or Dash coin). From the panels, it is clear that Bitcoin have the largest mean scores among these variables. Pertaining to their standard deviation which is the indicator of volatility, it is clear that the log of Ethereum has the highest, which indicates that it is more volatile. Moreover, the skewness and kurtosis show that the variables are positively skewed with positive kurtosis in their first differences. Although the values of kurtosis are extremely large, suggesting that the variables have excess kurtosis. Also, in their log-difference, the skewness of log-Bitcoin and log Ethereum was negative, suggesting that these variables are skewed to the left. In both Panels C and D, the Jarque-Bera statistics are all large, crossing the critical values of normal distribution of the variables. This means that these variables are not normally distributed

Table 4.1 Descriptive Statistics

	LNEXR	INFL	LNM2	LNBITC	LNETHR	LNDASC	LNGDP	LNOILP
Panel A: Log levels of Monthly								
Mean	2.467552	1.119941	7.398579	3.507116	1.919601	1.757921	7.829257	9.646962
Median	2.485792	1.096215	7.388708	3.800553	2.255659	1.909800	7.830992	9.711772
Maximum	2.580925	1.272306	7.576399	4.462424	3.048562	3.021884	7.888762	10.03277
Minimum	2.294444	0.968483	7.260176	2.361841	-0.131565	0.335943	7.748781	6.237678
Std. Dev.	0.080526	0.087102	0.077396	0.571747	0.853912	0.694453	0.029228	0.480908
Skewness	-1.173008	0.146993	0.398011	-0.584305	-0.991906	-0.524984	-0.624104	-5.63472
Kurtosis	3.647620	1.920421	2.522906	1.926891	2.864619	2.391192	3.756765	40.25173
Jarque-Bera	16.04202	3.390614	2.332601	6.817454	10.70831	3.989595	5.770692	4102.291
Probability	0.000328	0.183543	0.311517	0.033083	0.004728	0.136041	0.055835	0.000000
Sum	160.3908	72.79615	480.9076	227.9625	124.7741	114.2648	508.9017	627.0525
Sum Sq. Dev.	0.415003	0.485558	0.383368	20.92125	46.66658	30.86494	0.054675	14.80146
Observations	65	65	65	65	65	65	65	65

	DLNEXR	DINFL	DLNM2	DLNBITC	DLNETHR	DLNDASC	DLNGDP	DLNOILP
Panel B: Log Difference of Monthly data								
Mean	0.003831	0.003546	0.004835	0.032822	0.042725	0.024792	-0.002187	0.051162
Median	0.000000	0.002315	0.004453	0.029544	0.023656	-0.011023	-0.001898	0.002036
Maximum	0.104150	0.072967	0.037633	0.229500	0.500164	0.451204	0.006576	3.676266
Minimum	-0.041272	-0.031382	-0.016979	-0.196622	-0.333871	-0.281240	-0.007005	-0.86533
Std. Dev.	0.017866	0.017794	0.010301	0.093569	0.171936	0.152457	0.002180	0.490286
Skewness	3.632567	1.202119	0.714400	-0.061910	0.495799	0.818412	0.477084	6.372169
Kurtosis	20.28650	6.799153	4.299241	2.716323	3.277970	3.619214	5.821292	48.43188
Jarque-Bera	937.6143	53.90379	9.945321	0.255479	2.828087	8.166991	23.65367	5937.264
Probability	0.000000	0.000000	0.006925	0.880083	0.243158	0.016848	0.000007	0.000000
Sum	0.245186	0.226934	0.309425	2.100583	2.734402	1.586663	-0.139981	3.274372
Sum Sq. Dev.	0.020110	0.019947	0.006685	0.551572	1.862410	1.464310	0.000299	15.14395
Observations	64	64	64	64	64	64	64	64

Panel C: Log-Levels of Daily Data

	DLNBITC	DLNETHR	DLNDASH
Mean	0.001235	0.001613	-0.000588
Median	0.001676	0.001543	-9.62E-05
Maximum	0.225119	0.234741	0.451304
Minimum	-0.464730	-0.550732	-0.465459
Std. Dev.	0.041730	0.052654	0.062261
Skewness	-0.862714	-1.001428	0.262942
Kurtosis	15.42027	13.40007	13.35927
Jarque-Bera	9912.682	7071.568	6782.724
Probability	0.000000	0.000000	0.000000
Sum	1.869067	2.440304	-0.889024
Sum Sq. Dev.	2.632979	4.191960	5.861255
Observations	1147	1147	1147

Panel D: Log-Difference of Daily Data

	LNBITC	LNETHR	LNDASH
Mean	9.427089	6.154565	4.980224
Median	9.161262	5.886574	4.855901
Maximum	11.12087	8.478886	7.346558
Minimum	8.082329	4.434480	3.685717
Std. Dev.	0.828645	1.111781	0.722406
Skewness	0.669101	0.644711	0.863391
Kurtosis	2.261923	2.142926	3.320958
Jarque-Bera	147.3337	151.2223	194.5990
Probability	0.000000	0.000000	0.000000
Sum	14272.61	9318.012	7540.059
Sum Sq. Dev.	1038.906	1870.153	789.5910
Observations	1148	1148	1148

Source:

Author's computation from EViews 12

4.2 Unit Root Tests

Table 4.2 present the results of the test for conditional heteroscedasticity which is also known as the ARCH effect. This test uses a formal volatility test which is based on the autoregressive conditional heteroscedasticity (ARCH) test. This test uses various lags ranging from 5, 10, and 20.Table 4.2 : Results of test for conditional heteroscedasticity (ARCH effect) Note: ***, ** & * denote 1%, 5%, and 10% significance levels

TABLE 4.**2** RESULTS OF THE ARCH TEST

	ARCH(5)	ARCH(10)	ARCH(20)
DAILY RETURNS			
LNBITC	290.443***	78.1617***	48.6855***
LNETHR	241.741***	52.0414***	27.4963***
LNDASC	252.066***	42.9724***	26.7564***
LNGDP	645.35***	429.39***	230.45***
LNOILP	345.11***	234.69***	195.54***
MONTHLY RETURNS			
LNEXR	29.825***	17.690***	10.273***

The Unit Root results as shown in Table 4.2 show that all the variables exhibit an ARCH effect, which is normally found as a common characteristic of high frequencies. The presence of ARCH effect, therefore, indicates that GARCH-based model framework would be appropriate for the analysis of this study as demonstrated in Salisu et al. (2020) and Balcilar et al. (2021). Couple with this reason and the fact that higher frequencies of cryptocurrencies capture their returns volatility effects on the macroeconomic variables in a given country, we therefore adopt a framework that incorporates mixed data i.e. GARCH-MIDAS modeling technique. Table 4.3 below contains the GARCH-MIDAS analysis for the daily returns of bitcoins, Ethereum, Dash coins, oil prices, and GDP (converted to daily frequencies through quadratic interpolation) while, naira US dollar exchange rate, is in monthly frequencies.

4.3 Analysis from the Model

4.3.1 GARCH MIDAS Analysis of the Results

Tables 4.3 to 4.5 present the GARCH-MIDAS estimated parameters. From the results, μ denotes the conditional mean of the variables in returns. Both parameters α and β present ARCH and GARCH terms. These parameters are also known as the short-term component the conditional variance. θ is the sum of the weighted rolling window (i.e. a certain weighting scheme) exogenous variables which show the predictability of monthly variables (i.e. exchange rate, inflation, money demand on daily variables such as Bitcoins, Dash coins, and Ethereum, including controlled variables as such economic activity and oil price at national currency, i.e. naira. ω represents the adjusted Beta polynomial weight, and m denotes the long-run constant term. In estimating this model, we choose $k = 32$ which is appropriate as our weights approach the value of zero prior to lag 32.

This finding is the same when other dependent variables such as inflation and money demand is used as shown in Tables 4 3 to 4.5. Furthermore, the parameters μ and m are found to be statistically significant across the independent variables. Also, the parameter ω which shows the beta weight is statistically significant across the fundamental variables

The slope parameter of θ in the results reveal the predictability stance of the independent variables i.e. bitcoins, dash coins, Ethereum, economic activity, and oil price for dependent variables such as exchange rate, inflation, and money demand. From the results, we find that bit coins and dash coins have a positive and significant relationship with exchange rate while an increase in Ethereum have a negative and significant impact on exchange rate. This means that as trading in bit coins and dash coins increase, exchange rate rise (i.e. depreciation) while an increase in Ethereum would reduce exchange rate which is appreciation. However, when inflation is used as the dependent variables, the impact of bit coins on inflation is positive, indicating that an increase in trading bit coins leads to an increase in inflation in Nigeria, but an increase in dash coins and Ethereum reduces inflation in Nigeria with stronger impact noticeable when trading in Ethereum rises. Furthermore, our results provide that the impacts of economic activity and oil price are elastic, positive, and statistically significant in all the equations. This implies that an increase in economic activity through GDP and oil price would inflation, exchange rate (depreciation) and money demand in Nigeria.

Table 4.3 shows the results of the GARCH-MIDAS indicating the predictability of the Bitcoin, Ethereum and Dash coin cryptocurrencies as well as the controlled variables of economic activity proxied by the gross domestic product and oil prices. We find that the parameters α and β which represents the ARCH and GARCH terms respectively. are statistically significant and can also be predicted by the theory, whose sum of coefficients are less than 1. This shows that the means possess a reverting property or in other words, that the shocks to the dependent variable or in this case the exchange rate is likely to remain permanent and consistent for a longer time period before it disappears.

	Table 4.3 The GARCH-MIDAS Results on Exchange Rates					
	μ	α	β	θ	ω	m
lnBitc	0.0287***	0.0272***	0.9245***	1.7303***	2.3778**	0.0487***
	(0.0038)	(0.0058)	(0.3320)	(0.1277)	(1.1360)	(0.0017)
lnDasc	0.0189***	0.0169***	0.9731***	0.4998**	0.2236***	0.0506**
	(0.0028)	(0.0003)	(0.2583)	(0.0693)	(0.0259)	(0.0098)
lnEthr	0.0184***	0.2178***	0.6109***	-1.1875***	1.1545***	0.0483***
	(0.0036)	(0.0013)	(0.0342)	(0.4760)	(0.5725)	(0.0025)
lnGDP	0.6544***	0.0596***	0.8732***	3.3649***	1.8988***	0.0239***
	(0.0033)	(0.0107)	(0.0451)	(0.4692)	(0.5652)	(0.0006)
lnOilP	0.0061***	0.0908***	0.8104***	3.3161***	2.5052***	0.0217***
	(0.0023)	(0.0226)	(0.0975)	(0.1657)	(1.6990)	(0.0026)

Notes: The values in parenthesis are heteroscedasticity and autocorrelation consistent (HAC) stand errors. *** and ** show 1% and 5% significance levels.

4.3.2 Effect of Cryptocurrency Returns and Volatility on the Naira- United States Dollar Exchange Rate

The spillover Table for the returns and volatility of Bitcoins, Ethereum, and Dash Coin on the exchange rate is reported in Table 4.4 Table 4.5 respectively. These spillovers as shown in these tables are based on the first-order VAR with 6 variables. The Akaike Information Criterion (AIC) is used for selecting the optimal lag length of the model, and the lag selected is 1. The spillover analysis has been computed on the basis of $H = 10$-step ahead forecast error variance decomposition. The sum of the off-diagonal elements (column) provides "the contribution to others" which perhaps implies the total contribution of a certain variable to forecast error variance decomposition of other variables. Also, the sum of the off-diagonal elements (row) implies "the contribution from others", which perhaps measures the total contribution of shocks to other variables to the forecast error variance decomposition of a certain variable. Without the main diagonal elements, the individual elements in each column measure the contribution of each variable to the forecast error variance decomposition of other variables. In the same vein, the individual elements without the main diagonal, measure the contributions of the other variables to the forecast error variance (FEVD) of a particular variable. Furthermore, the percentage of the total spillover index is displayed in the lower right-hand corner of the spillover tables. The tables were generated based on the computation of the sum of all elements in the (6×6) matrix but without the sum of the diagonal elements.

Table 4.4 presents the effect of cryptocurrency returns spillovers on the Naira to one United States dollar exchange rate in Nigeria. From the results, it is clear that apart from the contribution of the main diagonals or the shock of each variable on itself, and the total shock from other variables outside the model. the shock from the bitcoin cryptocurrency had the largest impact on the Nigerian naira to one United States dollar exchange rate of about seven-point six percent (7.6%.). This is followed by a shock to Ethereum which is five-point two percent (5.2%) of the gross domestic product (GDP) has five percent (5.0%) while, Dash coins have four percent (4.0%). The effect of oil is extremely low at about one point one percent (1.1%). In addition, the results show that the exchange rate received a total contribution of about twenty-three percent (23.0%) from the forecast error variance decomposition of other variables while it transmitted about forty-eight-point five percent (48.5%) to the forecast error variance decomposition of other variables.

In terms of the bitcoin, the contribution received from other variables is about twenty-three-point two percent (23.2%) while, forty-two-point eight percent (42.8%) was transmitted to the FEVDs of other variables. Moreover, Ethereum received a total contribution of sixty-five-point nine percent (65.9%) from other variables while fifty-five percent (55.0%) was given to other variables. For the Dash coin, the contribution from other variables was forty-one-point six percent (41.6%), which was less than the ninety-three-point six percent (93.6%) transmitted to other variables in the model. The contributions received by Gross Domestic Product and

oil price from other variables were sixty-three-point nine percent (63.5%) and forty-six-point one percent (46.1%) respectively while about twenty-point three percent (20.3%) and about three-point, one percent (3.1%) was transmitted to the FEVDs of other variables. By implication, it means that ceteris- paribus, the Nigeran naira to one United States dollar exchange rate had a positive net spillover effect of twenty-five-point five percent (25.5%), implying that it made a positive impact on Nigeria's economy since the net effect of its operations on the demand for money in Nigeria was positive. Also, bitcoins, dash coins, and oil prices had positive net spillover effects, while variables such as Ethereum and gross domestic product had negative net spillover effects of minus ten-point nine percent (-10.9%) a negative forty-three point two percent (-43.2%) during the period under review. These positive or negative net spillover effects indicate the level each variable contributed to the forecast error variance decomposition of other variables, which was more (less) than what it received from the other variables in the model. In other words, the positive net spillover indicates that the variables are "net transmitters or givers" while, the negative net spillover implies that such variables were "net receivers".

The total spillover index which is provided in the lower right-hand corner of Table 4.4 is estimated to be forty-three-point nine percent (43.9%.) This implies that while, controlling for economic activity and oil price, the total effect of cryptocurrencies namely Bitcoins, Ethereum, and Dash coins on the Nigerian naira to one United States dollar exchange rate is less than fifty percent even though Nigeria holds more than fifty percent of its foreign currency reserves in United States dollar currency.

Table 4.4 Returns Spillover on Exchange Rate

	LNEXR	LNBITC	LNETHR	LNDASC	LNGDP	LNOILP	FROM OTHERS
LNEXR	77.0	7.6	5.2	4.0	5.0	1.1	23.0
LNBITC	1.3	76.8	0.2	14.5	7.0	0.3	23.2
LNETHR	0.9	11.3	34.1	48.8	4.7	0.2	65.9
LNDASC	10.0	10.8	20.6	58.4	0.2	0.1	41.6
LNGDP	27.4	0.2	20.1	14.5	36.5	1.4	63.5
LNOILP	9.0	12.9	9.0	11.8	3.4	53.9	46.1
Contribution to others	48.5	42.8	55.0	93.6	20.3	3.1	263.4
Contribution including own	125.6	119.6	89.1	151.9	56.8	57.0	43.9%
Net Spillovers	25.5	19.6	-10.9	52.0	-43.2	7.8	

Table 4.5 below presents the Effect of cryptocurrency volatility Spillover index on the Nigerian Naira to one United States dollar exchange rate/ The results of the Analysis as showed in the table, indicated that the effect of a shocks from the Bitcoin, Ethereum and Dash coin crypto currencies on the Nigerian naira to one United States dollar exchange rate during the review period. For example, that a shock from the Bitcoin crypto currency had an insignificant and negligible impact when compared to the effect of a shock from either the gross domestic product (GDP) or shock from changes in the international price of oil (OILP) on the Naira dollar exchange rate. That the highest mover of the Nigerian naira to one United States dollar exchange rate came from a shock from economic activity or economic growth with about three-point nine seven percent (3.7%.) This is followed by shocks from the Dash coin of about two-point three percent (2.3%) and from Ethereum that amounted to zero point six percent (0.6%). The shocks from oil price constituted about one- point- one percent (1.1%), which was the lowest of all the shocks impacting on the exchange rate. Furthermore, from the volatility spillover, it can be said that the shock transmitted from other variables to Ethereum has the highest with about thirteen-point three percent (31.3%). This is followed by shock to oil price i.e., about twelve-point seven percent (12.7%). The shock transmitted from other variables to bitcoins has the lowest percentage of four point eight percent (4.8%).

Table 4.5 Volatility Spillovers on the Naira-US dollar Exchange Rate

	LNEXR	LNBITC	LNETHR	LNDASC	LNGDP	LNOILP	FROM OTHERS
LNEXR	93.3	0.0	0.6	2.3	3.7	0.1	6.7
LNBITC	2.0	95.2	0.8	0.5	1.4	0.0	4.8
LNETHR	0.4	25.6	68.7	4.6	0.8	0.0	31.3
LNDASC	0.7	37.0	22.3	39.9	0.0	0.0	60.1
LNGDP	0.3	1.5	0.0	0.0	98.2	0.0	1.8
LNOILP	3.8	0.3	3.8	2.3	2.5	87.3	12.7
Contribution to others	7.2	64.5	27.5	9.8	8.5	0.1	117.5
ng own	100.5	159.7	96.2	49.7	106.6	87.3	19.6%
Net Spillovers	0.5	59.7	-3.8	-50.3	6.7	74.6	

4.3.3 Concluding Comments on the Analysis

A close examination of the findings of this study reveals that, while controlling for economic activity, measured by per capita GDP and oil prices, returns and volatility of cryptocurrencies such as bitcoins, Ethereum, and dash coins affect the exchange rate of naira and dollars. From the analysis, it is clear that the effect of Bitcoins is higher than any other cryptocurrencies. This is demonstrated in the contribution of bitcoins to the forecast error variance decompositions (FEVDs) of other variables, which include returns and volatility of Ethereum and dash coin as well as controlled variables, i.e. per capita GDP and oil prices. Specifically, the effects of bitcoins returns and volatility on the exchange rate of the naira and US dollars is positive. This suggests that bitcoins returns and volatility are important drivers of the exchange rate in Nigeria. For the case of dash coins, the effect is larger and significantly more noticeable in returns than in volatility. In other words, the effects of dash coins are positive only in returns while in volatility, they are negative. This suggests that dash coins receive less than what it transmits to other variables in returns while in volatility, it receives higher than what it transmits to the other variables. Finally, for Ethereum, the total effect on the exchange rate is negative in both returns and volatility. This suggests that Ethereum, although, affects the exchange rate, it receives higher than what it transmits to the other variables.

4.4 Test of Hypothesis

In this study, two null hypotheses were tested, namely:

H01: Cryptocurrency returns and volatility, particularly those of the Bitcoin, Ethereum and Dash coin have no significant effect on the Nigerian Naira – United States dollar exchange rate

H02: Bitcoin, Ethereum and Dash Coin Cryptocurrency return and volatility have significant effect on the efficacy of the monetary policy goals and outcomes of the Central Bank of Nigeria.

5.0 Summary, Conclusion and recommendations

5.1 Summary of main findings

Based on the empirical results discussed in this study, the three (3) main null hypotheses cannot be accepted. In other words, the sample data for this study provide us with evidence that cryptocurrencies returns and volatility from bitcoins, Ethereum, and Dash coins had significant effects on the Naira- United States dollar exchange rate, in Nigeria. Particularly, the total effect observed by these cryptocurrencies on the Naira-United States dollar exchange rate (i.e. hypothesis 1) was about 43.9% in the case of return and 19.6% for volatility. Given that the increasing trading of cryptocurrencies in the world of today, even though the monetary authorities in Nigeria, have recently discouraged their trading in the country, the continued use and adoption by individuals and businesses in the country, has implications for the efficacy of monetary policy goals, objectives and outcomes. This is due to the increasing globalization in monetary and financial services and since Nigeria cannot operation in isolation, it is only expedient that the regulatory and supervisory authorities like the SEC and NSE as well as the monetary authority like the Central Bank of Nigeria (CBN) have to find ways with which to best capture developments in cryptocurrency returns and volatility, especially those of the Bitcoin, Ethereum and the Dash coins, so as to achieve its broad adopt macroeconomic policy objectives of both internal and external balance. To achieve these broad objectives, attempts were made to model the relationship between developments in the returns and volatility of the Bitcoin, Ethereum and Dash coin cryptocurrencies and

three selected macroeconomic variables of Naira-United States dollar exchange rate, money demand and inflation during the period August 2015 to December 2021.

In this case, the GARCH-MIDAS regressions were performed using the returns and volatility of the dependent variables, which included the official naira-United States dollar exchange rate in Nigeria. Furthermore, we also analyzed both the returns and volatility of the effects of cryptocurrencies the Bitcoin, Ethereum and Dash coins on the Naira- United States dollar exchange rate in Nigeria using the recent Diebold-Yilmaz (DY) spillover index approach to complement our GARCH-MIDAS method. The DY approach is suitable for assessing the returns and volatility effects among variables by determining their directional spillovers, total spillovers, and net spillovers within the framework of the standard vector Autoregression (VAR(p)) model. To estimate these models, the descriptive statistics of the variables were analyzed. Furthermore, the time plots of the series were also analyzed for the possible presence of trends, drifts, seasonality, fluctuations, and structural breaks. Afterwards, the integrating properties of the variables were identified since the DY spillover index is based on the standard VAR(1) model. This means that the variables would be suitable only if it is integrated of order one [i.e.I(1)].

The major results of this study can be summarized as follows:

i. The variables in the model are all exhibiting fluctuations and structural breaks. However, in most variables, the evidence of trends are not significantly noticeable. In other words, some of the variables, there is no clear-cut evidence of trends.

ii. The variables mainly display a less volatility as shown through a less than unity values of most standard deviation. The descriptive statistics show that the skewness of the variables positive and negative in both the log levels and first differences. However, the kurtosis is show that all variables are positive with evidence of excess kurtosis in most of the variables. Comparing the values of descriptive statistics in the log levels and log first differences, it is clear that the values are higher in the formal than the latter. Hence the JB statistics of normal distribution are rejected in most cases. The rejections of the JB statistics signify that the variables are not normally distributed.

iii. The results of the traditional unit root tests reveal that all the variables are not stationary in their levels but after taking their first differences, all the variables become stationary. This implies that the variables are stationary in order one, [I(0)] process. This result is confirmed when the structural break unit root test is applied with evidence of structural break points.

iv. The results of the GARCH-MIDAS regressions show that cryptocurrencies such as Bitcoins, Ethereum, and Dash coins have a significant effect on the official Naira-United States dollar exchange rate, in Nigeria.

v. The results of the DY spillovers also revealed that the Bitcoin, Ethereum and Dash coin cryptocurrencies had significant effects on the official Naira-United States dollar exchange rate in Nigeria. Specifically, the effects of Bitcoins was higher than those of Ethereum and the Dash coin cryptocurrencies as the effects both in returns and volatility were positive, which suggests that bitcoins returns and volatility were important drivers of the official Naira-United States dollar exchange rate in Nigeria during the period 2015 to 2021. Furthermore, the effects of Dash coins was positive only in returns while in volatility, it was negative. This implies that the Dash coins received less than what it transmitted to other variables in returns while in volatility, it received higher than what it transmitted to the other variables. For the Ethereum cryptocurrency, its effects were negative in both returns and volatility, suggesting that it received higher than what it transmitted to the other variables.

5.2 Testing of the Hypothesis

In this study, the following null hypotheses formulated to guide the study are tested using the results of the GARCH-MIDAS and Diebold-Yilmaz spillover index:

H01: Cryptocurrency returns and volatility, particularly those of the Bitcoin, Ethereum and Dash coin have no significant effect on the Nigerian Naira – United States dollar exchange rate

H02: Bitcoin, Ethereum and Dash Coin Cryptocurrency return and volatility have significant effect on

the efficacy of the monetary policy goals and outcomes of the Central Bank of Nigeria.

Based on the empirical results discussed in this study, the null hypotheses cannot be obviously accepted. In other words, the sample data for this study provide us with evidence that cryptocurrencies returns and volatility from bitcoins, Ethereum, and dash coins have a significant effect on exchange rate in Nigeria. Particularly, based on the GARCH-MIDAS regression analysis, the results display that as cryptocurrency returns and volatility have a significant effect on exchange rate, and this effect is characterized by a mean reverting property. This suggests that the shocks to the exchange rate is likely to remain permanent and consistent for a longer time period before such effect disappears. This effect is positive in the case of bit coins and dash coins while in the case of Ethereum, the effect is negative. The positive effect suggests a depreciation of domestic currency while a negative effect suggests an appreciation of domestic currency.

Therefore, from hypothesis one, the null hypothesis that cryptocurrency returns and volatility from bitcoins, Ethereum, and dash coins have no significant effect on exchange rate is totally rejected while the alternative hypothesis which states that cryptocurrency returns and volatility from bitcoins, Ethereum, and dash coins have a significant effect on exchange rate is accepted. Furthermore, using the Diebold-Yilmaz spillover index approach, the null hypothesis is rejected too, suggesting that cryptocurrency returns and volatility have a significant effect on exchange rate of naira per US dollar. Hypothetically, the total effect observed by these cryptocurrencies on exchange rate is about 43.9% in the case of returns and 19.6% in the case of volatility.

In testing the hypothesis two, the GARCH-MIDAS regression and Diebold-Yilmaz spillover index are applied. From the GARCH-MIDAS regression results, it is observed that cryptocurrency returns and volatility from bit coins, Ethereum, and dash coins have a positive and significant effect on money demand in Nigeria. This effect is detected to be permanent and consistent for a long period and afterwards it vanishes. Therefore, it can be concluded that hypothesis two cannot hold, and hence we reject the hypothesis and state that cryptocurrency returns and volatility from bitcoins, Ethereum, and dash coins exert pressure on demanding for money. Moreover, on the basis of the results of the DY spillovers, the total effect of cryptocurrency (bit coins, Ethereum, and dash coins) on money demand is about 55.3% for returns and 22.0% for volatility. This also reject the null hypothesis that there is no significant effect of cryptocurrency returns and volatility on money demand in Nigeria.

The third hypothesis is equally tested using the results of the GARCH-MIDAS regression and DY spillover index. From the GARCH-MIDAS regression results, we discovered that cryptocurrency returns and volatility from bit coins, Ethereum, and dash coins have a significant effect on inflation in Nigeria, and this effect is permanent and consistent for a long time period before it disappears. Specifically, the effect of bit coins is positive and statistically significant over the period while the effect of Ethereum and dash coins are negative and statistically significant. This means that an increase in bit coins' return volatility increases inflation, while an increase in Ethereum and dash coins' return volatility decreases inflation. By this finding, we can conclude that the null hypothesis which states that cryptocurrency return volatility have no significant effect on inflation is reject while the alternative hypothesis which states that cryptocurrency return volatility have a significant effect on inflation is accepted. Furthermore, on the basis of DY spillover index, it is found that the total effect on inflation is 45.3% for returns and 24.1% for volatility. This means that the null hypothesis is rejected, suggesting that cryptocurrency return volatility from bit coins, Ethereum, and dash coins have a significant effect on inflation in Nigeria.

5.3 The GARCH-MIDAS findings

The results of the GARCH-MIDAS regressions show that cryptocurrencies such as bitcoins, Ethereum, and dash coins have a significant effect on the official exchange rate of naira to US dollars, year-on-year inflation in Nigeria, and money demand in Nigeria. Particularly, cryptocurrency return volatility from bit coins and dash coins exert upward pressure on exchange rate. This means that as bit coins and dash coins return volatilities are rising, unit of domestic exchange rate to US dollar is increasing which means depreciation of domestic currency. However, in the case of Ethereum, the effect is negative, suggesting appreciation of domestic currency. This result also hold for inflation and money demand equations. The few differences are, in the case of inflation, only bit coins return volatility is positively related to inflation, other cryptocurrencies such as Ethereum and dash coins have a negative effect on inflation. Furthermore, the effect of cryptocurrency return volatility is positive in the case of money demand. This suggests that as return volatility in cryptocurrencies increase money demand also increase. Generally, the effect of all cryptocurrencies were found to be permanent and consistent for a long time.

The results of the DY spillovers reveal that cryptocurrencies have a significant effect on official exchange rate of naira to US dollar, year-on-year inflation in Nigeria, and money demand in Nigeria. Specifically, the effect of Bitcoins is higher than any other cryptocurrencies as the effects both in returns and volatility are positive, which suggest that bitcoins returns and volatility are important drivers of exchange rate, inflation, and money demand in Nigeria. Furthermore, the effects of dash coins are positive only in returns while in volatility, they are negative. This implies that dash coins receive less than what it transmits to other variables in returns while in volatility, it receives higher than what it transmits to the other variables. For Ethereum, its effects are negative in both returns and volatility, suggesting that it receives higher than what it transmits to the other variables.

5.4 Conclusion

Given the broad objective of investigating the effects of cryptocurrencies on exchange rate, inflation, and money demand in Nigeria, the study adroitly make a conclusion based on the findings of this study that while controlling for economic activity and oil prices, cryptocurrencies namely; bitcoins, Ethereum, and dash coins have a significant effect on the exchange rate of naira to US dollar, inflation, and money demand in Nigeria. These effects are stronger in the case of bitcoins than other two cryptocurrencies (i.e. Ethereum and dash coins); although their effects are permanent and consistent for a longer time period before it disappears.

5.5 Recommendation

Based the findings of this study, the following policy recommendations are provided:

(i) There is a need for the monetary policy makers to intervene in the forex market in Nigeria in order to stabilize domestic exchange rate. In other words, monetary policy authorities should formulate policies using difference monetary policy tools to reduce the pass-through of exchange rate into the economy. This is because the recent empirical studies have identified exchange rate pass-through as responsible for the instability of domestic currency in Nigeria.

(ii) The announcement of the Central Bank of Nigeria not to recognize cryptocurrencies in Nigeria as a means of exchange and settlement of debts might not be the right policy decision to have reduced the effect of the cryptocurrencies in Nigerian economy. This is because, major economies in the world are interconnected due to the increasing pace of globalization across the world. Therefore, there is a need for the Central Bank of Nigeria to use monetary policy tools to reduce the global effect of cryptocurrencies on Nigerian economy.

(iii) In addition, the policy of inflation targeting introduced by the Central Bank of Nigeria recently is a right policy decision to stabilize the goal of price stability in Nigeria. Therefore, the monetary authorities need to pursue the inflation targeting policy within the rate stipulated without regulatory forbearance.

(iv) The growth of the economy is a necessary condition to stimulate economic development. However, efforts should be made by the monetary policy authorities so that such growth should not translate into inflation in Nigeria. This can be done by strengthening monetary policy tools combined with fiscal policies, targeting inflation reduction.

(v) Even though the transmissions of shocks from oil price to macroeconomic indicators are small, there is a need for the policymakers to strengthen the economy by using monetary policy instruments to dampen the channel of oil price-induced inflation in Nigeria.

6.0 Contribution to Knowledge

The main contribution of the study to knowledge is providing some empirical evidence oo the effect of cryptocurrency returns and volatility on the naira – US dollar exchange rate, money demand, and inflation in Nigeria, while controlling for economic activity captured by gross domestic product (GDP) and oil prices during the period 2015 to 2022, which has never been done before It's use of the GARCH-MIDAS regression approach complemented by the Diebold-Yilmaz Spillover index is another key contribution that would go a long way in guiding similar future studies in a developing import dependent oil exporting economy like Nigeria

The findings from the study are pioneer in nature and will help provide policy makers additional information for informed policy making and thus reduce the policy summersault encountered for lack of informed knowledge in policy making. The Empirical analysis is a major contribution to knowledge as it has updated the status of debate on the subject matter.

7.0 Limitations

The study did not cover the more than one thousand cryptocurrencies because it was practically impossible to do so. It only focused on the key cryptocurrencies, namely the Bitcoin and Ethereum, which control more than seventy percent of the cryptocurrency marketplace and the Dash coin to capture some of the features of the not so important but rising cryptocurrencies. The study did not cover all macroeconomic variables but restricted itself to the Nigerian Naira United States dollar exchange rate, money demand and inflation, leaving the remaining for subsequent studies to cover. It is also limited by time period in that it covered the period September 2015 to December 2021 and did not extend it to neither prior years nor the year 2022.

8.0 Areas for Further Research

Since this topic is less researched into empirically, especially with application to the Nigerian economy, there are many areas that would be of interest for further investigation. This includes studying to include more than three cryptocurrencies and more macroeconomic variables, examining them from a different perspective like using panel or cross section data instead of time series, studies and soon. Other areas worth considering would be looking at a group of countries with similar characteristics or countries across the development spectrum like one advanced plus an emerging and a developing country all together and compare the results to see whether they will be similar or display distinct differences because of their varied developmental levels. These are some of the wide array of studies that can be done in the future and make substantial contributions to knowledge/

9.0 References

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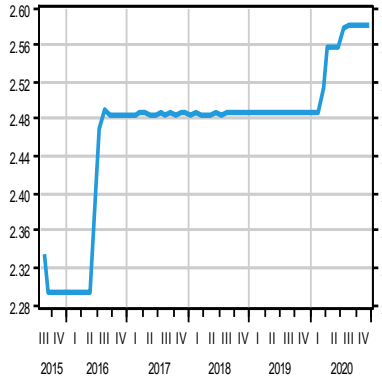
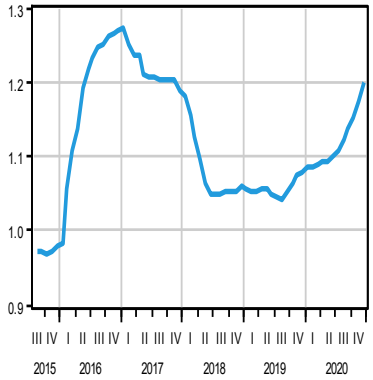
Fig. 4.1 Times Series Plot of Selectd Cryptocurrencies and key Macroeconomics Variables in the Study

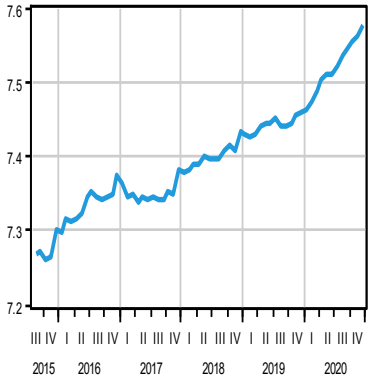
The Nigerian- Naira to One United States Dollar Exchange Rate 2015-2021



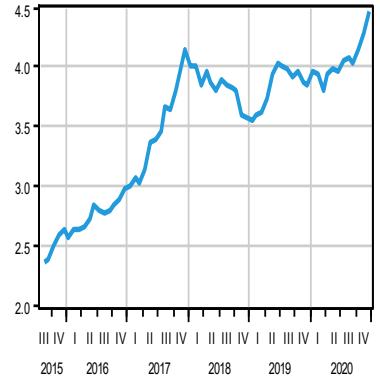
The Rate of inflation in Nigeria, 2015-2021



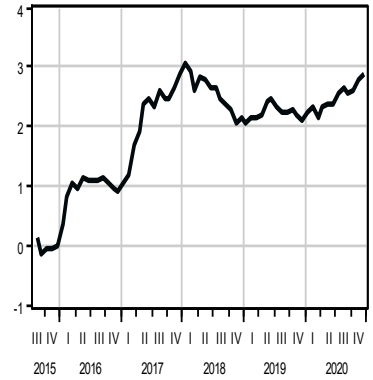
Money Supply in Nigeria 2015-2021



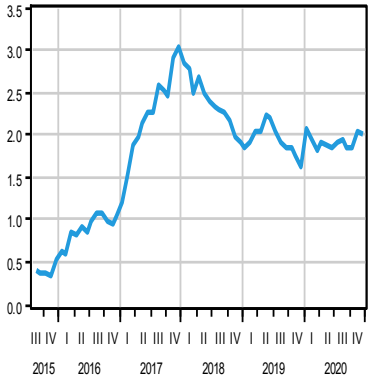
Trend in Bitcoin Prices 2015-2021



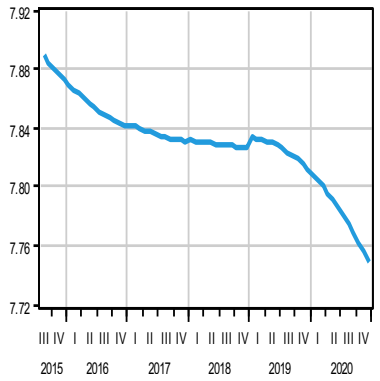
Trend in Ether Prices 2015-2021



Trend in the Dash Coin Prices 2015-2021



Movement in the Rate of Growth in GDP in Nigeria, 2015-2021



Movement in Price of Nigeria's Crude oil, 2015-2021

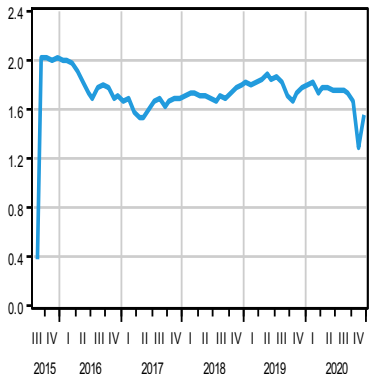


Figure 4.1: Time plot of Series in log-levels

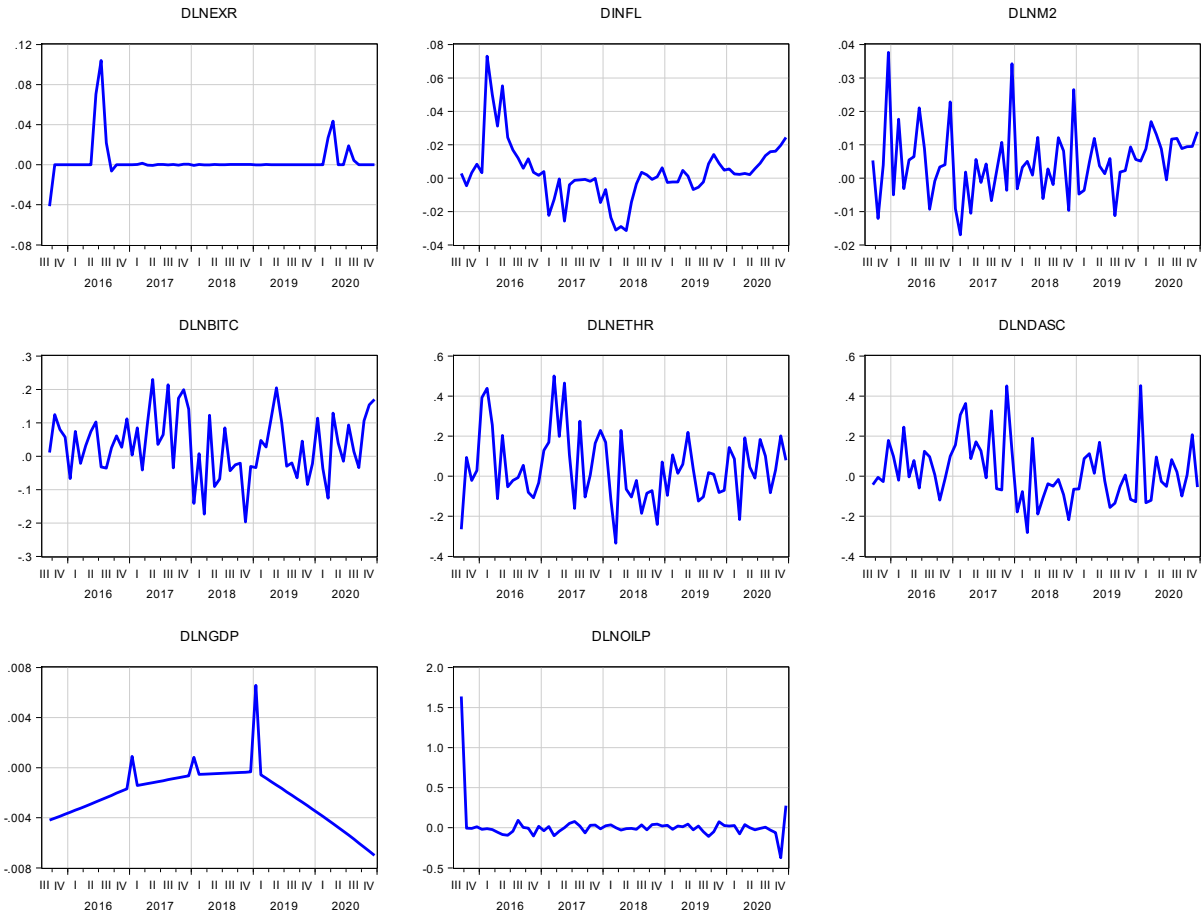


Figure 4.2: Time plot of Series in log-Difference