The Central Bank Digital Currency and Its Impact on Money Demand in Developing Economies: Evidence from Nigeria

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List of Abbreviations

CBDC- Central Bank Digital Currency

CBN- Central Bank of Nigeria

ARDL – Autoregressive Distributed Lag Model

ABSTRACT

The introduction of Central Bank Digital Currency (CBDC) has sparked significant interest among policymakers, financial institutions, and researchers due to its potential implications for monetary policy, financial stability, and money demand. This study investigates the impact of the eNaira, Nigeria's CBDC, on the demand for money, analyzing both short-run and long-run effects. Using an autoregressive distributed lag (ARDL) model, the study examines the relationship between CBDC adoption and traditional determinants of money demand, such as income, interest rates, inflation, and financial innovation. The empirical findings reveal a **dual effect** of CBDC on money demand. In the short run, CBDC adoption exhibits a **positive relationship** with money demand, suggesting that the introduction of the eNaira initially complements existing monetary aggregates by increasing transactional efficiency and fostering financial inclusion. However, in the long run, the results indicate a **negative relationship**, implying that sustained CBDC usage may lead to a decline in the demand for traditional money. This shift is attributed to disintermediation effects, reduced reliance on physical cash, and potential substitution effects as digital currency becomes more integrated into the financial ecosystem. These findings carry important implications for monetary policy and financial stability in Nigeria. The short-run increase in money demand suggests that CBDC can enhance liquidity and improve payment systems. However, the long-run decline in money demand raises concerns about the effectiveness of conventional monetary tools, such as interest rate adjustments and reserve requirements. Policymakers must therefore carefully manage the transition to digital currency, ensuring that it complements existing monetary policy frameworks while mitigating potential disruptions to the banking sector. Overall, this study contributes to the growing body of literature on digital currencies and monetary policy by providing empirical evidence on the evolving dynamics of money demand in the presence of CBDC. Further research is recommended to assess the broader macroeconomic effects of CBDC adoption, including its impact on financial intermediation, inflation dynamics, and economic growth in Nigeria.

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CHAPTER 1: INTRODUCTION

1.1 Background of the study

The financial sector has seen technological advancement that brought about the digital revolution in the industry with the emergence of mobile money, stablecoins, cryptocurrencies and Central Bank Digital Currencies. (Ozili, 2022a). A central bank digital currency (CBDC) refers to a fiat currency in electronic form issued by a central bank. Two types of central bank digital currencies exist. These are: wholesale and retail CBDCs. A retail CBDC is a form of central bank digital currency that is used by the general public while a wholesale CBDC is used by other banks and other licensed financial institutions for interbank payments and securities transactions (World Economic Forum, 2024). The rise in digital payment innovations has accelerated this cashless movement, particularly in developing and emerging economies (Ozili, 2023).

Debates about CBDC emerged in the global scene during the meteoric rise of private digital currencies or cryptocurrencies such as bitcoin in 2019. The global discussion on CBDCs reignited when the use of private digital currencies or cryptocurrencies, such as bitcoin, hit record levels in 2019. Most countries around the world included the possibility of adopting Central Bank Digital Currencies in their policy agendas, as the dynamics for economies and financial stability were generally debated actively by policymakers and economists among stakeholders in the industry. In addition, the central bank digital currency has been implemented in certain economies by China's central bank, the Central Bank of Bahamas, and the Central Bank of Nigeria (Ozili, 2021). In addition, countries like Sweden, Philippines, Japan, Turkey, Switzerland, and Ghana are testing their ability to issue a CBDC. By contrast, in countries such as the US, there has been no compelling reason to issue a CBDC.

The introduction of CBDCs have advantages and some disadvantages. Some advantages include promotion of financial inclusion, reduced transaction costs, provision of a secure and reliable means of payment and facilitation of cross-border payments which was a challenge with traditional fiat money. Some disadvantages include breach of privacy and security and high implementation costs.

Focusing on Nigeria, their central bank barred financial institutions from facilitating cryptocurrency transactions on the 5th of February 2021 dv (Ozili, 2021).

Soon after, in mid-2021 announced that it would issue a pilot central bank digital currency in October 2021 tagged "Project Giant". Their need to create a CBDC came in after aggregating factors from different sources such as issuance of the CBDC by other central banks and embrace of cryptocurrencies by Nigerian citizens (Ozili, 2021). Nigeria wanted to promote financial inclusion in their country which would in turn foster economic growth (Omoniyi Yemi, 2023). Financial inclusion proved to be the major challenge in regard to promoting the CBDC in Nigeria as the bulk of the money in the economy stays outside the banking system due to a lack of financial inclusion (Kama and Adigun, 2013). The bulk of adults in Nigeria remain excluded from digital payment solely depending on cash.

Furthermore, Nigeria is among countries in Sub-Saharan Africa that have a large number of people outside banking records (Ekong & Ekong 2022). As such, the Central Bank of Nigeria (CBN) sought to address this economic situation by introducing the eNaira (the central bank digital currency). The introduction of the eNaira came at a crucial time in Nigeria as most economies were still recovering from the adverse effects of the Covid-19 pandemic. Additionally, Nigeria was experiencing high inflation, significant depreciation of the Naira against major currencies, high public debt levels and high rates of unemployment with a significant portion of the population living below the poverty line.

Most research papers in regard to the CBDC focus on its implementation and adoption in various countries while also looking at impacts of the digital currency on financial inclusion. However, there is no study available about impact of the digital currency on money demand. Money demand involves "holding one's finance in the form of money, either cash or bank deposits rather than investments." (Investopedia). Most of Nigeria's population is unbanked and operate with cash but the CBN sought to reduce this statistic by introduction of the CBDC which could have a significant effect on money demand in the country. According to Pratham Rawat (2023), eNaira's uptake levels were still considerably low compared to their expectations indicating hesitance to use the eNaira as a form of payment. However, the number of uptake levels still have an effect.

The main question this research paper aims to answer is whether the eNaira affected money demand in Nigeria.

1.2 Problem Statement

Despite the promising potential of Nigeria's Central Bank Digital Currency (CBDC), the eNaira, to transform Nigeria's financial landscape, its actual impact on money demand remains unclear. The introduction of the eNaira aimed to foster financial inclusion, monetary policy, lowering of transaction costs, promote cross-border transactions and improve transaction efficiency. However, questions still linger on how it could influence cash and bank deposits and larger economic implications. These questions pose significant challenges for policymakers and stakeholders in trying to assess the CBDCs impact on various aspects of an economy.

This thus places an imperative need for the empirical and theoretical assessment of how the eNaira will affect money demand in Nigeria, taking into consideration factors such as adoption barriers, public perception, public trust in their financial systems, and economic factors like inflation, interest rates, and its role in the existing Nigerian financial system. Such dynamics are very critical in terms of maximizing the benefits of eNaira for optimizing policy actions and instructing fellow Central Banks toward continued economic stability and growth.

1.3 Research Objectives

1. Examine the short-run impact of the Central Bank Digital Currency on money demand in Nigeria.
2. Examine the long-run impact of the Central Bank Digital Currency on money demand in Nigeria.
3. Inform various developing Economies Central Banks.

1.4 Research Questions

1. What is the short-run impact of the CBDC on money demand in Nigeria?
2. What is the long-run impact of the CBDC on money demand in Nigeria?

1.5 Money Demand in Nigeria Over Time

Over time, money demand in Nigeria has been significantly influenced by various economic factors. Such factors include changes in economic growth, inflation rates and financial sector developments.

According to Ajisafe and Folorunso (2012), the demand for money in Nigeria has been influenced by factors such as income levels, interest rates and availability of alternative assets. With the Nigerian economy evolving through the years, the nature of money demand has shown drastic changes, reflecting the transitions in consumer behavior and monetary policy impacts on the economy (Ogunleye & Lawal, 2020). More crucially, from the very early days of high inflation in the late 1980s and early 1990s, there had been a move towards holding foreign currencies and assets even as a means of hedging against the devaluation of the naira. (Aluko & Olasehinde-Williams, 2021).

The central bank also used various monetary policies, aimed at stabilization and inflation control of the economy in the 2000s, which influenced demand for cash and bank deposits (Ajisafe & Folorunso, 2012). More recently, advancements in financial technology and introduction of digital payment systems have started to alter money demand patterns, with increasing adoption of mobile money and digital transactions. The eNaira further represents a crucial evolution of money demand, as it aims to integrate more Nigerians into the digital economy while addressing issues of financial inclusion and transaction efficiency.

1.6 Significance of The Study

It is important to understand how the eNaira would affect money demand, as this affects the effectiveness of monetary policy transmission, the velocity of money, and the inflationary pressures. The CBDC may reduce the use of cash, hence reduce the transaction cost, which in turn increases the effectiveness in the payment system. Second, it can improve financial inclusion in providing safe and affordable financial services to the population without bank accounts or underbanked people, particularly in rural areas.

Nonetheless, the CBDC also raises challenges such as risks on cybersecurity, demand for robust digital infrastructure, and if not well managed, challenges with the banking sector.

It therefore becomes necessary to evaluate the way through which the CBDC interacts with the other financial instruments that exist as well as its influence on the traditional demand for money which involves cash and bank deposits. The study of this impact is further important in ensuring a stable and all-inclusive financial environment within Nigeria.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The study of the impact of the Central Bank Digital Currency (CBDC) on money demand in Nigeria necessitates a comprehensive review of relevant theoretical and empirical literature. Existing research provides a foundation for understanding the dynamics of money demand, starting with the money demand function itself then notable frameworks such as the Baumol-Tobin model and Keynes's theory of demand of money which offer insights into how the digital currencies might alter traditional economic behaviors (Baumol, 1952; Tobin, 1956; Keynes, 1936).

Empirical evidence from developed countries piloting CBDCs such as China, suggests significant implications for monetary policy transmission and financial stability (Auer & Bohme, 2020). This literature review will delve into these perspectives to clearly bring out the potential effects of CBDC on Nigeria's money demand, considering both the theoretical underpinnings and practical insights from other global experiences.

2.2 Theoretical literature review

This paper discusses the money demand function and further discusses theories that have developed as a result of this money demand function.

The money demand function has roots in classical economics, but it was formalized in the early 20th century and later refined by key economists in the mid-20th century. This is a concept that models the relationship between the quantity of money that individuals and businesses wish to hold and several key economic variables such as interest rates, income, and price level (inflation). This function is usually expressed as MD= f (i, Y, Π).The symbols express classical determinants of interest rates(i), income(Y) and inflation(Π). When digital currency is issued, these determinants can be changed the in the following manner:

Interest Rates: If CBDCs bear some return or are somehow more attractive than the holding of cash in a physical form, they could impact the money demand function or how money demand changes with interest rates.

CBDCs may reduce the sensitivity of money demand to interest rates, since people could find it, after all, preferable to hold CBDCs even when interest rates are low.

Income: Digital currencies could improve transaction efficiency, particularly for digital payments, thus reducing the demand for money used in transactions. For example, with instantaneous settlements, the amount of money required to support a given level of income might decline.

Inflation: Whether CBDC is regarded to be a store of value may change the conventional link between this money demand and inflation. If a CBDC is considered safer than fiat money, it would not be as affected by higher inflation. In addition, the use of digital currencies could increase money velocity because the execution of transactions can lower due to their nature.

It would mean the need arise to make accommodative provisions in the modeling of the money velocity function since, using the traditional money demand function, the money velocity is an exogenous variable.

Discussed below are money demand theories that arose as a result of the money demand function.

Keynes's demand for money theory was proposed by John Maynard Keynes in 1936, and the theory is referred to as the liquidity preference theory. This theory was developed to address issues related to unemployment, interest rates and aggregate demand in an economy. Adding on to this, the theory speaks on the three motives of which a person's desire to hold money arises (Sonu Beniwal, 2019). There is the transaction demand for money, which states that people hold money in the form of cash balances for transaction purposes because receipt of money and payments do not coincide. The motive for holding money is simply the three key reasons as to why money is held. The first one being the transaction motive: under this, one may want to hold money because of transactions now and in the near future. Second is the precautionary demand for money; people holding under this motive hold money in cash or liquid in case of any unforeseen contingencies, for instance, sickness, danger of unemployment, and other uncertainties.

The last motive is speculative demand for money, meaning a desire for people to hold money in liquid form to take advantage of market movements regarding future changes in the rate of interest. Besides, the interest rates would account for a reflection of the opportunity cost of keeping money. When the interest rate is high, people would like to occupy interest-bearing assets rather than cash, thus lowering the demand for money; vice versa applies (Sonu Beniwal, 2019).

This theory informs this study by identifying how the introduction of the CBDC might alter the public's cash holding behavior. For instance, the CBDC can reduce the need for physical cash by making digital transactions more efficient and accessible.

Also, the secure and inclusive nature of the CBDC can increase its desirability for precautionary purposes and the CBDC's ability to offer a stable store of value might attract those who hold money for speculative reasons. Additionally, with the CBDC, the velocity of money might increase due to more efficient and faster transactions, affecting the overall money supply and demand. The Central Bank's ability to control interest rates and implement monetary policy could be enhanced by the widespread adoption of the CBDC, influencing money demand dynamics. However, this theory primarily addresses the demand for physical cash and traditional bank deposits. It does not adequately consider the unique characteristics and functionalities of digital currencies such as enhanced security features and programmability which can also influence money demand behaviors.

The second theory is the Baumol-Tobin money demand theoretical framework. This theory is considered a step-up from the Keynes's theory of demand for money. It was established through the independent work of William J. Baumol and James Tobin in the 1950s. This theory analyzes the trade-off between holding cash and interest-bearing assets to minimize the total cost of managing cash balances (Intact One, 2023).

It assumes that people hold money to spend on buying goods and services, settling bills, and other payments. More importantly, it postulates that the needs of people for money are based on the motivation of minimizing the cost of managing transactions (Intact One, 2023). It means, unlike for speculation, people actually hold money to save on the cost of conducting transactions (Intact One, 2023). According to this approach, people determine the amount of money to hold based on three factors.

These are Income, interest rates and cost of goods and services. People with higher incomes tend to have higher transaction costs because they tend to spend more thus require more money to make transactions. People can also earn interest by investing in interest-bearing assets. If interest rates are high people may choose to hold less money and invest more and vice versa. Lastly, when prices of goods and services increase, people also require more money to make transactions. This theory fits into this study through the main thesis of the theory. The demand for money is determined by the need to reduce transaction costs (Intact One, 2023). The CBDC streamlines payment processes, reducing the costs and time associated with transactions. Additionally, with reduced transaction costs, individuals and businesses might adjust their optimal cash balances.

This model, however, only takes into consideration the demand for money in transaction purposes and does not account for the demand for money for other purposes such as speculation and precautionary motives. meaning that the CBDC would only be helpful in reducing transaction costs.

2.3 Empirical Literature Review

Bolt and Van Oordt (2016) explored the potential substitution effects of digital currencies on traditional money. The article emphasized that digital currencies, especially ones like Bitcoin, could substitute for traditional money under certain conditions (Badev & Chen, 2014). The conditions include factors like increased security, lower transaction costs and higher convenience. However, the degree of substitution depends on the acceptance and trust in digital currencies. The study also referenced the importance of network effects, that is, the value of a digital currency increases the more people use it, creating a positive feedback loop that accelerates adoption (Gandal & Halaburda H, 2014). The network effect also influences competition between digital currencies and traditional fiat money, as well as among different digital currencies themselves. The study further highlighted that the larger the network of users, the more attractive the digital currency becomes. This in turn leads to increased market liquidity, enhanced security and reduced transaction costs.

Further, the authors noted that significant substitution of traditional money with digital currencies could reduce the effectiveness of central banks in controlling money supply and interest rates. (Rogoff, 2016).

However, the substitution effect is likely to be gradual as digital currencies are susceptible to challenges like volatility and limited acceptance which may hinder their widespread adoption. The study employed a dynamic stochastic general equilibrium model to analyze the value and impact of digital currencies.

The model integrated the choice between using traditional money and digital currencies for transactions making sure to account for factors like security features and anonymity of digital currencies. This model enabled them to analyze how changes in macroeconomic variables could impact overall demand for digital currencies and their potential to disrupt traditional monetary systems. Additionally, they drew on prior work related to the economics of payment systems and built on frameworks developed by Kiyotaki and Wright (1989) and Lagos and Wright (2005).

(Bordo & Levin, 2017) analyzed how digital currencies could impact monetary policy and the demand for money.

The authors argued that CBDCs could enhance the effectiveness of monetary policy, especially in environments where traditional policy tools are constrained, such as near-zero interest rates. Further by allowing central banks to implement negative interest rates on digital currency holdings, CBDCs could mitigate the zero-bound problem, which limits the scope of monetary policy during economic downturns. Additionally, it was stated that due to the monetary economists reaching a broad consensus that the conduct of monetary policy should be systematic and transparent, the introduction of the CBDC would propel this initiative further. Also, the central bank would still retain its capacity to serve as a lender of last resort. That is in case of a financial crisis, central banks would be able to increase quantities of CBDCs in order to provide emergency liquidity to certain approved financial institutions (Bordo & Levin, 2017).

Moreover, the paper suggested that CBDCs could stabilize money demand by offering a risk-free, digital alternative to cash and bank deposits, which may become increasingly attractive in a digital economy.

This stability is particularly crucial as it enables central banks effectively control inflation and manage economic cycles (Adrian & Mancini-Griffoli, 2019).

The study employed a theoretical and conceptual analysis to assess the implications of CBDCs. It draws from existing economic models and drew evidence from fields such as monetary policy and financial stability in order to hypothesize effects of CBDCs. The paper did not conduct empirical literature but rather synthesizes existing literature to make predictions about the future impact of CBDCs.

(Rulmin Song, Tiantian Zhao & Chunhui Zhou, 2024) analyzed the impact of the Central Bank Digital Currency on the demand for transactional currency in China. The study also noted that there was less empirical analysis of the research on the effects of the Central Bank digital currencies on the demand for money as a research object. Secondly, the researchers refined the Baumol-Tobin model and the transactional money demand function was constructed based on the features of the digital currency that is Central Bank Digital Currencies.

Additionally, quarterly data from the year 2010 to 2022 was selected to test the relationship between CBDCs and transactional money demand through the Auto-Regressive Distributed Lag Model (ARDL).

They further argued that holding cash was an opportunity cost to the public and that holding cash in the present meant foregoing the interest income from investing it. Additionally, a legal tender was introduced. According to (Smith & Johnson, R,2023), a legal tender is an official currency designated by law, which must be accepted in the settlement of public and private debts. With the introduction of CBDCs, residents would hold assets in three forms: interest-bearing assets, cash and Central Bank Digital Currencies (CBDCs). Consequently, under the Central Bank Digital Currencies condition, a large portion of residents' cash holding would be replaced by the digital currencies. This is because the Central Bank Digital Currencies do not incur transaction fees. This results in a crowding out effect on the credit cash, reducing the transactional money demand.

The study also highlighted the fact that conversion costs and opportunity costs were two important factors affecting the demand for transactional currencies. CBDCs do not require payment of transaction fees to third-party institutions.

The development of the legal tender on the other hand gave rise to a trend of gradual monetization of financial assets that is, interest-bearing assets with high yields and high liquidity at the same time. Therefore, the public would be able to quickly convert interest-bearing assets into transactional currencies to satisfy their daily payment needs without the need to hold more transactional currencies, reducing the opportunity cost of holding transactional currencies. For model construction and data selection, there was use of a semi-logarithmic transactional money demand function and an autoregressive distributed lag model (ARDL). Specific variables were used. These were the explained variable transactional money demand, the core explanatory variable (as the digital yuan had not yet been launched to the public), the gross domestic output, conversion costs and opportunity costs.

An Augmented-Dickey Fuller (ADF) test and a marginal cointegration test were conducted. Then the ARDL model was run and estimated. Results were the following; both in the long and short-run, legal tender, opportunity costs, and total output greatly affected the demand for transactional currency. Finally, in the long term, the positive elasticity of inconvenience of legal tender affects the structure of currency demand in China by curtailing transaction currency demand due to the attractiveness and security of legal tender. Thus, the paper concluded that there was a significant negative relationship between legal tender and transactional moneys demand, with legal tender significantly reducing the demand for transactional money in both the short and long run, thus causing the instability of the moneys demand structure.

The study also advanced relevant recommendations according to the present situation of the legal tender development in China. The first recommendation was that the central bank should continue with the underlying technical support foundation of the Central Bank Digital Currencies. Secondly was to make continuous and active promotion of public awareness of the Central Bank Digital Currency. It is important to enhance the scale and strength of the legislative framework and policies that underpin the industry concerning Central Bank digital currencies.

2.4 Research Gap

The first study talks about the potential substitution effect of the CBDC on money demand while the second study talks about the potential impacts of the CBDC on money demand. This second study however, only hypothesizes these potential impacts as they did not have real data to work with. The third study looks at the impact of the CBDC on money demand in China. However, no study has been conducted in reference to a developing economy that has subsequently introduced a digital currency, which in this case is Nigeria. At the time the above studies were being conducted, central bank digital currencies were in their pilot stages and there was no real data to work with. It is imperative to conduct a study on Nigeria to ascertain whether or not the results will match or differ given the two countries are very different in terms of economic structure, financial inclusion levels and cultural and behavioral differences.

Some differences worth noting include the economic structure and financial inclusion levels. China's economy is more developed with a higher rate of financial inclusion and digital literacy compared to Nigeria hence the adoption levels in Nigeria might differ significantly due to a larger informal sector, lower access to digital infrastructure and varying levels of trust in digital financial systems. This creates a need to study how these factors influence the demand for a CBDC and its acceptance in Nigeria. Also, technological infrastructure differs. China's advanced digital payment infrastructure supported by widespread smartphone use and internet access facilitated the adoption of the digital yuan while Nigeria's technological infrastructure, while still growing, still faces challenges such as limited internet penetration and varying levels of access to smartphones.

All these factors create necessary gaps that may influence Nigeria's outcomes and subsequently its impact on money demand. Hence, the need to study Nigeria's case.

2.5 Policy Implications

Regulatory challenges and opportunities presented by digital currencies in frontier economies. The major potential opportunities that are likely to be associated with digital currencies in frontier economies are regulatory in nature, though some can be purely positive, with financial systems that are predominantly underdeveloped.

Notable among those challenges are money-laundering risks, financial system instability, and lack of set regulatory frameworks to guide digital currencies. The regulatory authorities in these regions find a difficult balance between innovation and risk management, mostly because the authorities here lack resources and expertise to provide adequate oversight over the burgeoning landscape of digital currency.

However, they also open up avenues for financial inclusion, as they include unbanked populations in access to financial services. Digital currencies have the potential to facilitate cross-border transactions, reduce transaction costs, and enhance efficiency in remittance flows, particularly in countries with limited traditional banking infrastructure. It has been postulated that digital currencies will spur economic growth by bringing in the informal economies into formal financial systems, thereby expanding the tax base and improving the stability of the economy. (Narayanan et al., 2016; Catalini & Gans, 2018).

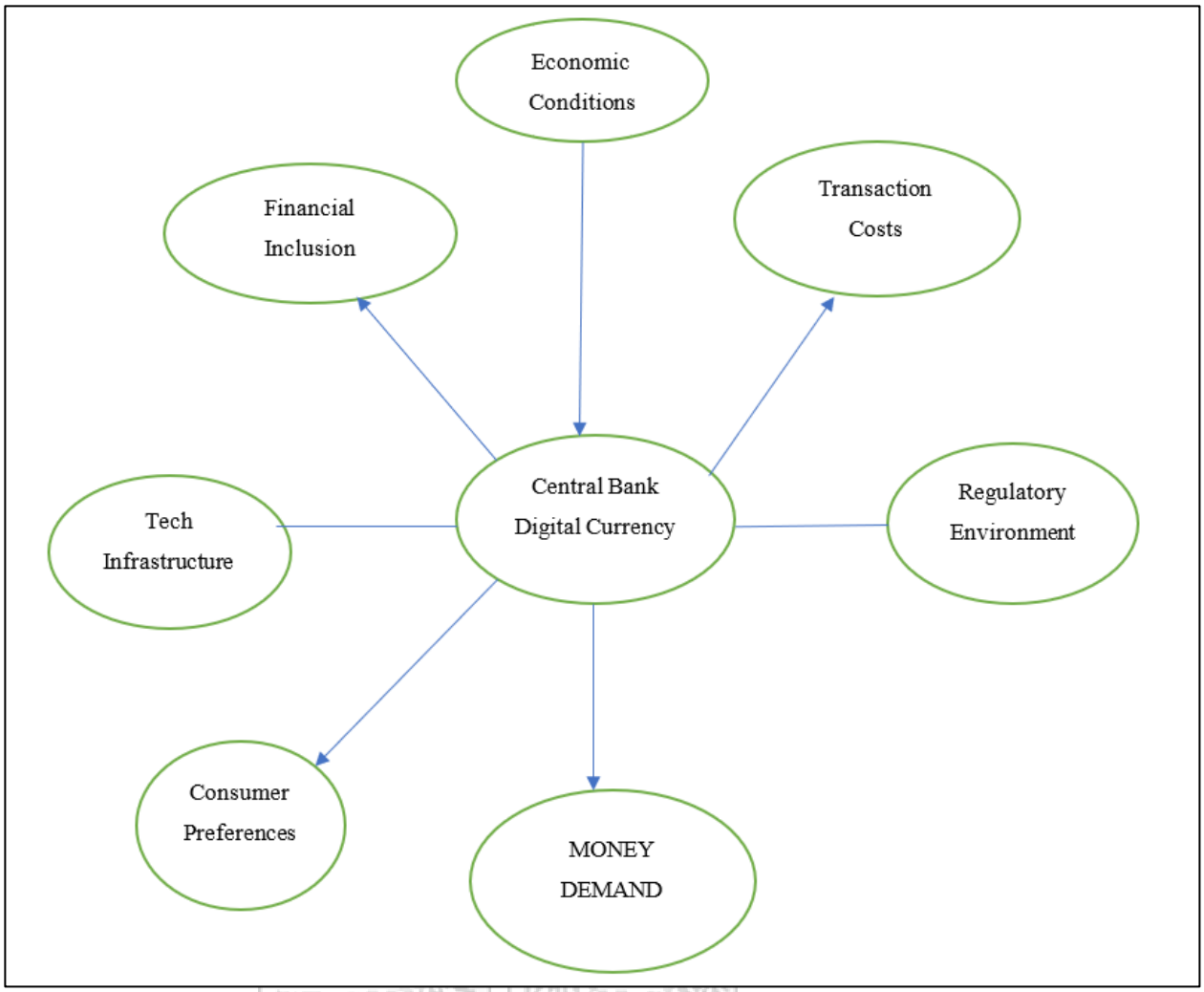
Nevertheless, the successful adoption of digital currencies in frontier economies requires comprehensive regulatory frameworks that address these challenges while fostering innovation. Collaborations between international organizations, local governments, and private sectors could help establish standards and best practices for digital currency regulation. Moreover, capacity-building initiatives are essential to equip regulators with the knowledge and tools needed to manage the unique risks and opportunities associated with digital currencies in these regions (Mishra, 2020; Adrian & Mancini-Griffoli, 2019).

2.6 Conceptual Framework

The conceptual framework for studying the impact of the Central Bank Digital Currency (CBDC) on money demand in Nigeria would involve several key components and relationships that define how the Central Bank Digital Currency might impact various aspects of money demand. The dependent variable is money demand which is the demand for money in Nigeria, which includes various forms of money such as cash or bank deposits. The independent variable is the Central Bank Digital Currency (CBDC).

Other variables that could impact the Central Bank Digital Currency and therefore impact money demand are financial inclusion levels, transaction costs and consumer preferences. Furthermore, economic conditions such as interest rates, inflation levels and income levels also play a crucial role.

Diagrammatical representation of conceptual framework



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CHAPTER 3: METHODOLOGY

3.1 Introduction

Here, the assumptions and approaches used in this work are presented. It consists of the type of design, methodology, population of the study, various types of variables, and a source of data. This also clarifies the various steps in data analysis and tools that will be necessary for carrying out the study.

3.2 Research Design

The research design of an exploratory nature refers to a design used in research when a problem or an issue under study is not clearly defined, or when the researcher wants to obtain insights, clarify concepts, or explores new interests. This will help to establish a relationship between the different variables at hand and allow for inferences to be made about the resulting associations and causality perceived. Again, the relationship between the Central Bank Digital Currency and money demand is one that remains unexplored in the Nigerian context at this perusal. This study gives a better understanding of the relationship—within this research; conclusions are drawn and weighed against the previous conclusions of various studies conducted in developed economies, China to be exact.

3.3 Population and sampling

This study is a case study on the impact of the Central Bank Digital Currency(eNaira) on money demand in Nigeria. Only Nigerian related sample was considered for the various variables.

3.4 Data Collection

The study to be conducted would utilize time series data since there is only one country under consideration in the study, that happens to be Nigeria. Secondly, most of the published secondary data to be used is sourced from numerous sources.

It would require quantitative data inputs of monetary aggregates, quantum of CBDC transactions, and other macroeconomic variables like Gross Domestic Product (GDP) and the rate of inflation that can be used as control variables, which could be obtained via the data archives at the Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS), and Nigerian Inter-bank settlement System (NIBSS). The considered period for analyzing this model is from 2011 to 2023.

This is to enable comprehensive analysis of Nigeria's money demand way before the introduction of the Central Bank digital currency, during its introduction, and most importantly after. Other critical changes to note that occurred in this period and that could also affect the demand for money include the 2016 and 2017 recession fueled by the drastic fall in global oil prices, reduced income in the country leading to an uptick in inflation and unemployment, therefore more reliance on cash as it is a safe asset during the period of fluctuations. The persistent inflation and devaluation of naira has equally impacted the purchasing power of the Nigerian populace.

Increased prices led to fluctuating demand for money especially cash as people needed more currency to maintain their standard of living. Additionally, the depreciation of the Naira led to an increase in the demand for foreign currencies to hedge against inflation further influencing money demand dynamics. Lastly, the Covid-19 pandemic also had an effect on money demand in Nigeria. Social distance measures, lockdowns and fear of transmission of the virus accelerated adoption of digital payments and contactless transactions.

This uncertainty greatly shifted money demand dynamics as some people withdrew large sums of cash as a precautionary measure while others purely moved towards digital channels.

3.5 Diagnostic checks

3.5.1 Unit Root Tests

The standard classical methods of estimation are usually based on the assumption that all the variables at one's disposal are stationary. However, in reality, this may not be the case for most of the macro-economic variables as observed by Baltagi in 2008. This kind of problem leads to what is often referred to as spurious regressions.

It is thus important for stationarity tests to be carried out on the variables prior to the study; it is going to help avoid the dilemma of spurious regressions. Most of the time, non-stationary variables become stationary after differencing.

However, to yield accurate and reliable results, stationarity tests should be carried out before it can be concluded that the variables are stationary. The assumption is that with an increase in sample size, the covariances of the sample converge to the covariances of the actual population. Since there are non-stationary variables present, this would not happen because they do not fluctuate around a constant mean (Verbeek, 2004). There is a problem that would also arise if two completely unrelated non-stationary variables were regressed together.

It basically would likely mislead anyone by the fact that a high R2, different from auto-correlated residuals, are high regression coefficients in relation to their standard errors.

A number of approaches have been developed which will help us test for unit roots. The most commonly used include: the Dickey-Fuller test, the Augmented Dickey-Fuller, and the Phillips-Perron test. In this study, I will use the ADF test. The ADF test is, in essence, a standard DF test but now done in the presence of auto-correlated errors. Due to this fact, the ADF test is preferred to the DF test simply because it considers error corrections, takes care of them, and uses lagged values, which does not apply in the DF test. If one uses this test to estimate the model, when the p-value obtained is greater than 0.05, the null hypothesis is rejected. Accepting the null hypothesis means a unit root, hence the series are not stationary.

3.5.2 Cointegration tests

Differencing would then yield a stationary series, which in many ways is more desirable. However, by doing this, we lose the long-run characteristics to estimation, which is also not desirable. Although individually, these variables are not stationary, the linear combination of two or more variables can be stationary, and hence there might exist cointegration and long-run relationship between non-stationary variables of a system. Therefore, to obtain both the short-run and long-run relationship, cointegration is very important and essential.

The most common procedure is the Johansen Maximum Likelihood procedure.

In contrast with the other possibility, the Engle Granger procedure, Johansen tests allow for testing for more than one cointegrating vector. It allows estimation of the model without having the restriction of classifying variables as either endogenous or exogenous. In such a way, it is possible to test for plural cointegrating relationships in a single step procedure.

In these, non-stationary time series variables—whose means and variances move over time—shall be able to be analyzed with cointegration tests and enable the estimation of long-run parameters in the system that would be intended to be observed and reported.

3.6 Model Specification

This research considers a model that effectively handles time-series data, particularly when variables are of mixed integration orders. The model chosen is the Autoregressive Distributed Lag (ARDL) model. This model does not require all variables to be stationary.

It further allows for estimation of both short-term and long-term dynamics within a single framework, making it particularly suitable for examining the relationship between the CBDC and traditional determinants of money demand such as interest rates, income and inflation in Nigeria.

The model typically takes the following form:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-1} + \sum_{j=0}^{q} \beta_j X_{1,\,t-j} + \sum_{k=0}^{q} \gamma_k X_{2,\,t-k} + \ldots\ldots\ldots\ldots + \epsilon_t$$

Where:

Y_t is the dependent variable; in this case money demand

$X_{1,\,t,}$ $X_{2,\,t,}$ ……. are the independent variables which in this case are the CBDC, interest rates, income levels (measured by GDP) and inflation levels.

A_i , β_j , γ_k are the coefficients.

P, q_1, q_2 represent the lag lengths.

ϵ_t is the error term.

CHAPTER 4: DATA ANALYSIS

4.2 Lag Selection Criteria

The process of determining the optimal lag length is crucial in time series modeling as it impacts the accuracy of estimations and forecasts. For this analysis, the lag-order selection criteria were applied to the variables log_MoneyDemand, CBDC_Vol, Interest_Rate, log_GDP, and Inflation, using the "varsoc" command. The criteria considered in the output in Table 4.1 below includes the Log Likelihood (LL), Likelihood Ratio (LR) test, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC).

Table 4.1: Lag selection criteria models

Lag-order selection criteria

Sample: **2011q1** thru **2023q4** Number of obs = **52**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-127.182				.000111	5.08393	5.15586	5.27155
1	359.769	973.9	25	0.000	2.1e-12*	-12.6834*	-12.2518*	-11.5577*
2	379.356	39.175	25	0.035	2.7e-12	-12.4752	-11.684	-10.4114
3	392.743	26.773	25	0.367	4.6e-12	-12.0286	-10.8777	-9.02666
4	418.423	51.36*	25	0.001	5.1e-12	-12.0547	-10.5442	-8.11471

* optimal lag

Endogenous: **log_MoneyDemand CBDC_Vol Interest_Rate log_GDP Inflation**

Exogenous: **_cons**

The results indicate that a lag length of 1 is optimal for the model. This conclusion is drawn from the fact that all the selection criteria such as FPE, AIC, HQIC, and SBIC reach their minimum values at lag 1. For instance, the Final Prediction Error (FPE) is 2.1e-12 at lag 1, which is significantly lower than at other lag lengths, indicating improved predictive accuracy at this level. At the same time, the AIC, HQIC, and SBIC values at lag 1 (−12.6834, −12.2518, and −11.5577, respectively) are the lowest across all tested lags, suggesting that this lag length provides the best balance between model fit and complexity. Furthermore, the LR test strongly supports lag 1, with a highly significant test statistic of 973.9 (p=0.000), confirming that adding this lag significantly improves the model fit.

As the lag length increases beyond 1, the selection criteria values begin to rise. For instance, at lag 2, the AIC increases to −12.4752, and the FPE rises to 2.7e-12, indicating diminishing returns by including additional lags. Considering lag 3 and beyond shows that the criteria continue to worsen, which suggests that higher lag lengths add unnecessary complexity without improving the model's explanatory power. Therefore, the results strongly favor a model with a single lag.

The choice of a lag length of 1 has several implications for the study. First, it ensures efficiency by reducing the risk of overfitting while maintaining sufficient information about the dynamic relationships between the variables. A single lag also makes the model easier to interpret, particularly in the context of understanding the effects of the Central Bank Digital Currency (CBDC) on money demand. In this case, simpler models also tend to yield more stable estimates, which is essential for conducting robust analyses, especially when transitioning to tests for stationarity, cointegration, or applying the ARDL or ECM frameworks.

Subsequently, the analysis will consider the optimal lag length for modeling the relationships among log_MoneyDemand, CBDC_Vol, Interest_Rate, log_GDP, and Inflation as 1, because it is supported by all major selection criteria. This choice provides a foundation for subsequent analyses and ensures that the model captures the dynamics of the variables without unnecessary complexity.

4.3 Unit Root Test: Analysis and Interpretation

The Augmented Dickey-Fuller (ADF) test was applied to assess the stationarity of the variables Money Demand, CBDC Volume, Interest Rate, GDP, and Inflation as presented in Table 4.2 below. Stationarity is a critical property in time-series analysis because non-stationary data can lead to misleading results in regression models. The ADF test examines the null hypothesis (H0) that a series has a unit root (non-stationary), against the alternative hypothesis (H1) that the series is stationary. Below, we discuss the results for each variable in detail, followed by an interpretation of their implications.

Table 4.2: Summary of unit root tests using ADF model

Variable	*ADF Statistic*	*Critical Value (5%)*	*p-Value*	*Stationary?*
log_MoneyDemand	−2.429	−2.927	0.1337	No
CBDC_Vol	3.389	−2.927	1.0000	No
Interest_Rate	−5.312	−2.927	0.0000	Yes
log_GDP	−2.746	−2.927	0.0663	No
Inflation	−7.922	−2.927	0.0000	Yes

The results show that log_MoneyDemand, CBDC Volume, and log_GDP are non-stationary in their levels, while Interest Rate and Inflation are stationary.

The ADF test statistic for Money Demand is −2.429, which is less negative than the critical value at the 5% significance level (−2.927). The p-value associated with the test is 0.1337, which is greater than the conventional threshold of 0.05. Consequently, the results accept the null hypothesis that Money Demand has a unit root. This result indicates that Money Demand is non-stationary in its level form, suggesting that its statistical properties, such as mean and variance, change over time. This non-stationarity may reflect underlying trends or persistent shocks in the data, likely due to structural changes in Nigeria's economy or fluctuations in monetary policy.

The ADF test statistic is 3.389, which is significantly above the critical values at all conventional significance levels. Additionally, the p-value is 1.000, confirming that the results accept the null hypothesis. This indicates that CBDC Volume is also non-stationary at its level. The non-stationary nature of CBDC Volume is unsurprising, as its adoption and usage might follow a progressive growth pattern, especially given the recent introduction of digital currencies like the eNaira. This non-stationarity reflects the evolving adoption trends and usage volumes over time, influenced by factors such as policy changes and public acceptance.

The ADF test statistic for Interest Rate is −5.312, which is more negative than the critical values at all significance levels (−3.574, −2.927, and −2.598).

The corresponding p-value is 0.000, rejecting the null hypothesis and concluding that Interest Rate is stationary in its level form. Stationary interest rates imply that their fluctuations are short-term and revert to a mean over time. This stationarity is consistent with the fact that central banks actively manage interest rates through monetary policy interventions to maintain economic stability.

The ADF test statistic for log_GDP is −2.746, which is greater than the critical value at the 5% significance level (−2.927). Additionally, the p-value is 0.0663, leading to acceptance of the null hypothesis. This indicates that GDP is non-stationary at its level. GDP's non-stationary behavior aligns with economic growth trends, as GDP is generally influenced by long-term economic developments and may exhibit upward trends or structural breaks over time. This result suggests that GDP will need to be differenced to achieve stationarity before proceeding with further analysis.

The ADF test statistic for Inflation is −7.922, which is much more negative than the critical value at the 5% significance level (−2.927). The p-value is 0.000, rejecting the null hypothesis and concluding that Inflation is stationary in its level form. The stationarity of inflation is consistent with the expectation that inflation rates fluctuate around a certain range because of the monetary policy measures aimed at controlling price stability. Stationary inflation indicates that deviations are temporary and revert to a mean value over time.

The results indicate that log_MoneyDemand, CBDC Volume, and log_GDP are non-stationary in their levels, while Interest Rate and Inflation are stationary. Before conducting further analyses, it will be necessary to transform the non-stationary variables by differencing them to achieve stationarity. This transformation is essential for avoiding spurious regressions and ensuring reliable estimates in cointegration and regression models. The stationary variables, Interest Rate and Inflation, can be used directly in models without further adjustments.

The non-stationary nature of other variables highlights the need to consider long-term trends and persistent shocks in the Nigerian economy when analyzing the effects of the eNaira and other macroeconomic factors. These results also set the foundation for subsequent cointegration tests, which will determine whether the non-stationary variables share a stable, long-term relationship.

4.4 Cointegration Test

We conducted the Johansen cointegration test to ascertain the existence of a long-term equilibrium relationship among the variables log_MoneyDemand, CBDC volume, interest rate, log_GDP, and inflation. This test is particularly important in analyzing non-stationary time series, as it helps identify whether these variables move together over time, despite short-term fluctuations. The analysis uses the trace statistic to assess the number of cointegrating relationships (denoted as r), with the null hypothesis (H0) stating there are r cointegrating vectors. We ran the test under the assumption of a constant trend, selecting two lags based on previous lag selection criteria.

Table 4.3: Johansen cointegration test results

Johansen tests for cointegration

Trend: Constant — Number of obs = 54

Sample: 2010q3 thru 2023q4 — Number of lags = 2

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	30	308.23811	.	167.2452	68.52
1	39	339.05933	0.68067	105.6027	47.21
2	46	364.59897	0.61167	54.5234	29.68
3	51	378.31218	0.39824	27.0970	15.41
4	54	391.86062	0.39456	0.0001*	3.76
5	55	391.86069	0.00000		

* selected rank

The results of the Johansen cointegration test show the presence of up to four cointegrating relationships among the variables. For rank 0 (no cointegration), the trace statistic is 167.2452, which exceeds the 5% critical value of 68.52. The results reject the null hypothesis of no cointegration, indicating the existence of at least one cointegrating relationship. At rank 1, the trace statistic decreases to 105.6027 but remains above the 5% critical value of 47.21, suggesting the presence of at least two cointegrating relationships. Similarly, at rank 2, the trace statistic is 54.5234, which is still greater than the 5% critical value of 29.68.

This confirms that there are at least three cointegrating relationships. At rank 3, the trace statistic is 27.0970, which also exceeds the 5% critical value of 15.41, suggesting the presence of a fourth cointegrating relationship.

However, at rank 4, the trace statistic drops to 0.0001, which is below the 5% critical value of 3.76. This result accepts the null hypothesis, indicating that there are no more than four cointegrating relationships.

The findings confirm that money demand, CBDC volume, interest rate, GDP, and inflation share a stable, long-term relationship, as evidenced by the presence of four significant cointegrating vectors. These relationships highlight the interconnectedness of the variables in Nigeria's economic context. For instance, prevailing economic conditions, such as inflation and GDP growth, could influence the adoption of CBDC and its influence on money demand, thereby maintaining long-term equilibrium. Similarly, changes in interest rates may play a stabilizing role in this system by adjusting monetary dynamics over time.

The presence of cointegration has important implications for further analysis. First, it justifies the use of models such as autoregressive distributed lag (ARDL) model and Error Correction Model (ECM), which can capture both the short-term dynamics and long-term relationships among the variables. These models play a crucial role in comprehending the correction of deviations from equilibrium over time. Second, it underscores the necessity of considering interdependencies when assessing the impact of CBDC adoption on money demand in Nigeria.

For instance, any policy interventions targeting CBDC usage must account for their potential long-term effects on macroeconomic variables like inflation and GDP.

The use of the Johansen test provides robust evidence of four cointegrating relationships among the variables. This finding reinforces the hypothesis that money demand, CBDC volume, interest rate, GDP, and inflation are not independent but instead exhibit a stable equilibrium relationship over the long term. Such insights are crucial for policymakers seeking to understand the systemic impact of digital currencies and their integration into Nigeria's monetary framework.

4.5 ARDL and ARDL Error Correction Model Analysis

The Autoregressive Distributed Lag (ARDL) model and its associated Error Correction Model (ECM) were estimated as shown in Tables 4.4 and 4.5 below, to examine the short-run and long-run relationships between log_MoneyDemand (dependent variable) and the independent variables CBDC Volume, Interest Rate, log_GDP, and Inflation. The results are presented and analyzed below in detailed paragraphs.

4.5.1 Analysis of the ARDL Model

The ARDL model was estimated using one lag for each variable, capturing the dynamics between current and lagged values of the dependent and independent variables. The regression results are summarized in Table 4.4 below.

Table 4.4: ARDL model results

Variable	β	SE	t-value	p-value	95% Confidence Interval
log_MoneyDemand (L1)	0.8505	0.061	13.95	0.000	[0.7277, 0.9733]
CBDC Volume	1.3795	1.502	0.92	0.363	[-1.6457, 4.4046]
CBDC Volume (L1)	-2.9623	1.5328	-1.93	0.06	[-6.0495, 0.1250]
Interest Rate	-0.8677	0.746	-1.16	0.251	[-2.3703, 0.6349]
Interest Rate (L1)	-0.7507	0.758	-0.99	0.327	[-2.2773, 0.7759]

log_GDP	0.0657	0.0378	1.74	0.089	[-0.0104, 0.1417]
log_GDP (L1)	-0.0391	0.0384	-1.02	0.313	[-0.1164, 0.0381]
Inflation	0.1113	0.3657	0.3	0.762	[-0.6252, 0.8479]
Inflation (L1)	0.5994	0.3821	1.57	0.124	[-0.1703, 1.3691]
Constant	-9.3305	31.7426	-0.29	0.77	[-73.2634, 54.6024]

The coefficient for the lagged dependent variable (log_MoneyDemand, L1) is statistically significant (p = 0.000), with a value of 0.8505. This indicates strong persistence in Money Demand, as past values significantly influence current values.

The short-run coefficients for most independent variables, including CBDC Volume, Interest Rate, and Inflation, are not statistically significant at the 5% level. However, the lagged value of CBDC Volume approaches significance (p = 0.060), suggesting some evidence of a delayed effect of CBDC adoption on Money Demand. The overall model fit is excellent, with an R^2 value of 1.0000, indicating that the independent variables explain nearly all the variation in Money Demand. However, this high R2R^2R2 should be interpreted cautiously due to potential overfitting or multicollinearity.

4.5.2 Analysis of the ARDL Error Correction Model (ECM)

The ARDL error correction model (ECM) was estimated to analyze short-term adjustments and long-term relationships. The results are summarized in Table 4.5 below.

Table 4.5: ARDL Error Correction Model Results

Variable	Coefficient	Std. Error	t-value	p-value	95% Confidence Interval
ECT (log_MoneyDemand, L1)	-0.1596	0.0616	-2.59	0.013	[-0.2836, -0.0355]
CBDC Volume (LR)	-12.0292	3.8582	-3.12	0.003	[-19.7999, -4.2585]
Interest Rate (LR)	-2.5793	4.8392	-0.53	0.597	[-12.3259, 7.1674]
log_GDP (LR)	0.1855	0.0201	9.24	0.000	[0.1451, 0.2260]
Inflation (LR)	0.1301	2.1863	0.06	0.953	[-4.2733, 4.5335]

CBDC (SR)	Volume	3.2976	1.5188	2.17	0.03 5	[0.2386, 6.3566]
Constant		-11.7654	30.026 9	-0.39	0.69 7	[-72.2427, 48.7120]

The adjustment coefficient (ECT, L1) is statistically significant (p = 0.013) with a value of −0.1596, indicating that approximately 16% of deviations from the long-run equilibrium are corrected each quarter. This demonstrates the presence of a stable long-term relationship among the variables, with adjustments occurring gradually.

In the long run, CBDC Volume has a significant negative relationship with Money Demand (−12.0292, p=0.003), suggesting that higher CBDC adoption reduces traditional Money Demand. Similarly, GDP positively impacts Money Demand (0.1855, p=0.000), implying that economic growth increases the demand for money. However, Interest Rate and Inflation do not have statistically significant long-term effects.

In the short run, changes in CBDC Volume (D1) have a significant positive effect on Money Demand (3.2976, p=0.035), reflecting immediate adjustments in response to changes in CBDC adoption.

4.5.3 Diagnostic Test for Serial Correlation

The Durbin's alternative test for autocorrelation was performed as shown in Table 4.6 below. The results of analysis yielded a p-value of 0.4261. Because the p-value exceeds 0.05, the results accept the null hypothesis, which indicates no evidence of serial correlation in the residuals. This confirms the reliability of the estimated models.

Table 4.6: Durbin's alternative test for autocorrelations

Durbin's alternative test for autocorrelation

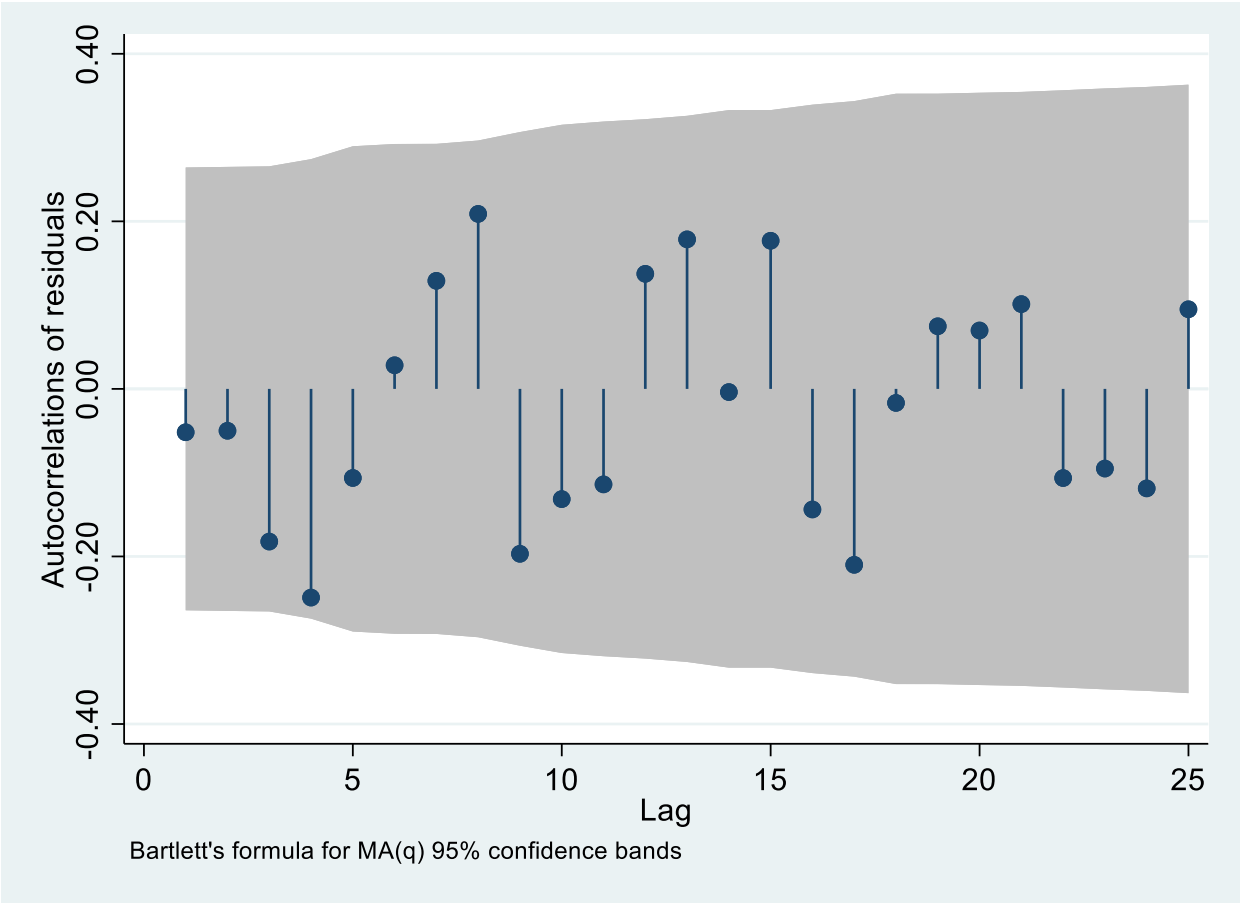
lags(*p*)	chi2	df	Prob > chi2
1	**0.633**	**1**	**0.4261**

H0: no serial correlation

The results of the autocorrelation function (ACF) plot in Figure 4.1 below shows that the residuals appear to be randomly distributed with no significant spikes in autocorrelation.

This is an indication that the model has effectively captured the dynamics of the data, and there is no serial correlation. In the two main models to test short- and long-term relationships.

Figure 4.1: Autocorrelation function plot



4.6 Summary of the Findings

The ARDL model results reveal strong persistence in Money Demand, as indicated by the significant lagged dependent variable (L1), while the lagged effects of CBDC Volume approach significance in the short run. Although the model demonstrates an excellent fit, potential multicollinearity issues should be considered. The ECM results confirm the presence of stable long-term relationships among the variables, as evidenced by the significant error correction term (ECT). In the long run, CBDC Volume has a significant negative impact on Money Demand, whereas GDP positively influences it, highlighting the role of economic growth in driving money demand.

In the short run, changes in CBDC Volume have a significant positive effect on Money Demand, reflecting immediate adjustments in response to changes in CBDC adoption. These findings underscore the nuanced impact of CBDC adoption on Money Demand in Nigeria, offering valuable insights for policymakers and economic modeling efforts.

CHAPTER 5: CONCLUSION

5.1 Study Summary

This study explored the relationships between Money Demand, CBDC Volume, Interest Rate, GDP, and Inflation in Nigeria using time-series econometric methods. The first key step was determining the optimal lag length for the analysis using the lag selection criteria, which indicated that a lag length of 1 was most appropriate. The Augmented Dickey-Fuller (ADF) test was then employed to assess the stationarity of the variables, revealing that Money Demand, CBDC Volume, and GDP were non-stationary at their levels, while Interest Rate and Inflation were stationary. This led to the differencing of the non-stationary variables to achieve stationarity for further analysis.

Following this, the Johansen cointegration test was conducted, confirming the existence of three significant cointegrating relationships among the variables. The Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM) were then estimated to examine both short-term and long-term dynamics. The ARDL model highlighted the strong persistence of Money Demand and suggested that the lagged effect of CBDC Volume approaches significance in the short run. The ECM revealed that while GDP positively impacts Money Demand in the long run, CBDC Volume has a negative long-term effect, signaling a shift in the demand for traditional money with increased adoption of digital currencies. The study also examined the reliability of the models through diagnostic tests, including the Durbin's alternative test for autocorrelation, which confirmed no serial correlation in the residuals.

5.2 Implications of the Study

The findings of this study have several important implications for policymakers, particularly in the context of the evolving role of Central Bank Digital Currencies (CBDC) in Nigeria. The results indicate that CBDC Volume has a significant long-term negative impact on Money Demand, suggesting that as digital currencies become more widely adopted, the demand for traditional forms of money may decrease. This has significant implications for monetary policy and the broader financial system. Policymakers need to consider these potential effects when planning for the future role of digital currencies, ensuring that their adoption does not destabilize the existing monetary system.

Additionally, the study found that GDP has a positive long-term impact on Money Demand, indicating that economic growth leads to higher demand for money. This reinforces the importance of fostering economic stability and growth to ensure the stable functioning of monetary policies. The finding that Interest Rates and Inflation had limited short-term effects in this context suggests that while these variables are critical in long-term economic stability, their immediate impact on money demand may be less pronounced compared to the other factors examined.

The study's findings also highlight the complex interdependencies between the variables in Nigeria's economy. The identification of cointegration among the variables underscores the need for integrated policy approaches that consider both short-term dynamics and long-term equilibrium relationships. Policymakers must ensure that changes in one variable, such as CBDC adoption, do not lead to unintended consequences for other key variables like inflation and interest rates.

5.3 Conclusion

In conclusion, this study provides a comprehensive analysis of the dynamic relationships between Money Demand, CBDC Volume, Interest Rate, GDP, and Inflation in Nigeria. The application of ARDL and ECM models has offered valuable insights into the short-run and long-run interactions among these variables. The findings suggest that while CBDC adoption may reduce traditional money demand in the long term, GDP remains a key driver of money demand, highlighting the role of economic growth in shaping monetary dynamics. The presence of cointegration further supports the hypothesis of a stable long-term relationship among the variables, allowing for more effective modeling and policy interventions.

The study also emphasizes the importance of model selection and stationarity testing in time-series analysis, as these steps ensure the reliability and accuracy of the results. Through the use of cointegration tests and error correction models, the study has provided a robust framework for understanding the long-term and short-term effects of digital currency adoption in Nigeria.

5.4 Recommendations

Based on the findings of this study, several recommendations are made for policymakers and future research.

Firstly, monetary authorities should carefully consider the long-term implications of CBDC adoption on traditional money demand. While digital currencies can offer efficiencies and financial inclusion, their widespread adoption may lead to a reduction in the demand for physical currency. Therefore, policymakers need to prepare for potential changes in monetary policy tools, such as adjusting interest rates or regulating the supply of CBDCs, to maintain economic stability.

Secondly, as GDP positively influences Money Demand, it is recommended that policymakers focus on fostering economic growth through investment in infrastructure, innovation, and other growth-promoting policies. A stable, growing economy will naturally support increased demand for money, ensuring that monetary policies continue to function effectively.

In the short term, changes in CBDC adoption should be monitored closely, as they have immediate effects on money demand. Policymakers must ensure that the transition to digital currencies is gradual and that any short-term volatility in money demand is managed through appropriate adjustments to monetary policy.

Finally, further research is needed to explore the long-term effects of CBDC adoption on broader macroeconomic variables, such as inflation and interest rates. Comparative studies involving other developing economies could provide a deeper understanding of the systemic effects of digital currency adoption in different contexts, enriching the global discourse on this issue.

This study finally provides a comprehensive understanding of the relationship between digital currency adoption and traditional monetary dynamics in Nigeria, offering valuable insights for policymakers tasked with managing the introduction of CBDCs and their integration into the broader monetary framework.

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APPENDICES

Appendix I: STATA Program Code

programs*

```
**STATA PROGRAM TO FOR ARDL AND ADRL EC
*reading data
*browse

*setting quartly time-series data
gen qdate = tq(2010q1) + _n - 1
format qdate %tq
 tsset qdate

*lag selection criteria model
  varsoc log_MoneyDemand CBDC_Vol Interest_Rate log_GDP Inflation

*stationarity test using ADF models at optimum lag 1
 dfuller log_MoneyDemand, regress lags(1)
 dfuller CBDC_Vol, regress lags(1)
 dfuller Interest_Rate, regress lags(1)
 dfuller log_GDP, regress lags(1)
 dfuller Inflation, regress lags(1)

*Johansen cointegration test
 vecrank log_MoneyDemand CBDC_Vol Interest_Rate log_GDP Inflation, trend (constant)

 *installing the autoregressive distributed lag (ARDL) model library
 ssc install ardl

*running autoregressive distributed lag (ARDL) model
  ardl log_MoneyDemand CBDC_Vol Interest_Rate log_GDP Inflation, lags(1,1,1,1,1)

 *running autoregressive distributed lag (ARDL) error correction model
  ardl log_MoneyDemand CBDC_Vol Interest_Rate log_GDP Inflation, ec

 *serial autocorrelation diagnostic test using Durbin's alternative model
 estat durbinalt

*graphical representation of autocorrelation tests for the ardl models:
*residuals vs. time plot
predict resid, residuals
tsline resid, ytitle("Residuals") xtitle("Time") title("Residuals over Time")

 *autcorrelation function (ACF) plot
 ac resid

 *partial autocorrelation plot
 pac resid
```