

The Evolution of Money and the Changing Role of Central Banks in the Digital Age

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Abstract

As a medium of exchange, money has evolved throughout the ages from barter system to fiat money issued by central banks. The digital age has ushered in new realities for central banks, transforming the nature of money and challenging monetary authorities to new roles required to implement their core mandate of maintaining monetary and price stability. The main purpose of this paper is to examine the changing roles of central banks occasioned by the challenges posed by digitalisation. Based on available literature surveyed, this changing role is principally evident in the recent move by most central banks to issue their own digital currencies with a view to achieving orderly conduct of payment systems already threatened by the proliferation of private digital currencies. This paper submits that in order to enhance their chances of success and maintain trust in their digital currencies, central banks should continuously innovate, in partnership with private firms, as well as rise to the challenge of the key forces likely to shape the path of any Central Bank Digital Currency project including changing user needs, competitive pressure from private digital currencies, complex regulations and cybersecurity threats.

Keywords: money, central banks, digital age, digital currency, CBDC forces, innovation diffusion model

JEL Classification: E40, E58, O31

I. Introduction

A system of exchange has evolved throughout history starting with barter to commodity money and to fiat money- a central bank issued currency not backed by a commodity such as gold. In order to maintain the value of fiat money derived from the public's faith and trust in the issuer, central banks attempt to control the supply of money using a number of tools in pursuit of their core mandate of maintaining monetary and price stability.

The digital age has brought with it electronic forms of money and payment systems which are now challenging central banks to new roles required to implement their core mandate. Today, a major concern of Central Banks is

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that private digital currencies or cryptocurrencies, with their decentralised system and peer-to-peer technology, have the potential to upset payment systems in which they superintend. Moreover, beside many drawbacks including a limited supply and potential to serve as a vehicle for illicit activities, cryptocurrencies do not enjoy the same degree of trust that citizens have in fiat currencies. As a result, a number of central banks are now borrowing elements of cryptocurrency technology to explore issuing their own digital currencies.

Barely a year after it launched Africa's first Central Bank Digital Currency (CBDC) on October 25, 2021, the Central Bank of Nigeria (CBN) has joined the growing list of countries including India, Turkey, China and Brazil to introduce a national domestic card scheme, with effect from January 16, 2023, in line with its mandate to promote stability in the financial and payment system.

Indeed, the digital revolution is transforming the nature of money, payments systems and role of central banks. How is the advent of new forms of money in the digital age such as decentralised cryptocurrencies influencing the mandate of central banks? This paper examines the changing roles of central banks occasioned by the challenges posed by digitalisation using available literature.

The rest of the paper is organised as follows: beginning with the concept of money, Section II reviews relevant Literature on new forms of money and implications for central bank roles; Section III discusses lessons learnt in the context of the four forces likely to shape implementation of a CBDC project; Section IV draws some conclusions while Section V presents some policy recommendations.

II. Literature Review

Beginning with the concept of money, this section examines the evolution of money, traditional roles of central banks, new forms of money in the digital age and the changing roles of central banks. Also, it takes a brief look on the Innovation Diffusion theory upon which the adoption of new technologies is often anchored.

II.1 Concept of Money

Money is any asset that is generally accepted in exchange of goods and services and in settlement of debt. It is 'simply anything of value that is

accepted by the general public for the purpose of making transactions and settlement of debts. In most cases, money is regarded as currency (notes and coins) because it is easily used in making payments. However, money is more than currency in that it includes other things that are used for transactions'' (Central Bank of Nigeria, 2016:1).

Money serves three basic functions: it is a medium of exchange, a store of value and a unit of account which enables the measurement of value (Jantsankhorloo, 2019). Money supply is the sum of all money or monetary assets that can easily be converted to cash in an economy at any given time.

Central banks define money supply in two ways: narrow and broad money. Narrow money (M1) is defined to include currency in circulation plus current account deposits with commercial banks. Broad money measures the total volume of money supply in the economy and is defined as narrow money plus savings and time deposits with banks including foreign denominated deposits. In Nigeria, the different measures of money supply known as monetary aggregates are: monetary base, narrow money and broad money (Central Bank of Nigeria, 2021).

The monetary base M0 is expressed as:

$$M0 = C + R \quad (1)$$

Where C is currency in circulation which is the sum of currency outside banks plus currency in the vaults of banks and R represents the cash reserves of banks with the Central bank.

Narrow money M1 is the sum of currencies in circulation (all paper notes and coins) and demand deposits (balances in current accounts)

$$\text{Hence, } M1 = C + DD \quad (2)$$

Broad Money M2 consists of all components of narrow money, Savings Deposits (SD), Time Deposit (TD) and foreign denominated deposits (FD)

$$\text{Hence, } M2 = M1 + SD + TD + FD \quad (3)$$

Some central banks, including the Central Bank of Nigeria, also have a broader definition of money supply (M3) which is M2 plus Repurchase agreements, long tenured deposits with maturity of up to two years, deposits

redeemable at notice of up to three months, money market fund shares/units and debt securities up to two years.

II.2 Evolution of Money

Throughout history, the system of exchange has moved from exchanging goods for goods known as bartering, to swapping animal skins and precious metals to minting coins and printing paper money (Glyn, 2016). Today, technological advancements have enabled users to carry virtual currency in their mobile devices, like smartphones, and even brought forth the concept of digital currencies. Indeed, money has evolved from fiat to digital currencies over the years as two novel forms of currency emerged in the 21st century namely mobile payments and virtual currency.

A new chapter in the history of money was opened following the invention of bitcoin, the first cryptocurrency or crypto asset by a man using the pseudonym, Satoshi Nakamoto, in 2009 (Bozma & Akdag, 2021). Following this development, it would appear that monetary systems have historically alternated between commodity and credit money. As documented by He (2018), during the 20th century, money was essentially based on credit relationships. While, on the one hand, central bank money represented a credit relationship between the central bank and the citizens with respect to cash and between the central bank and commercial banks in relation to reserves; on the other hand, commercial bank money in the form of demand deposits represent a credit relationship between the bank and its customers. In contrast, cryptocurrencies are not based on any credit relationship and are more like commodity money.

II.3 Money in the Digital Age

The digital age is considered by Lengsfeld (2019) as the period in the course of human history that is characterised by digital information and communication technologies. This age, also known as the information age, is the age of digital revolution. One notable feature of this age is the magnitude and speed of digitalisation which is pronounced in the payment system.

Prior to the digital revolution in the payment landscape, retail payments were only available using cash and cheques. Today, these payment methods are gradually given way to digital money. Digital money is any form of money that exists only in electronic form. In contrast to physical currencies such as banknotes and minted coins which are tangible, electronic money lacks tangible form. Transactions involving digital currencies are made using

computers or electronic wallets connected to the internet. Digital money can be transferred with technologies such as smartphones, and online cryptocurrency exchanges. In fact, the advent of cryptocurrency unlocked a new era of currency digitalisation. Juhro (2022) notes that the digital revolution within the payment system has brought with it elevated opportunities and risks and to this extent has implications for financial system stability. Much as digital currencies enable seamless transfer of value and can result in lower transaction costs, cyber-attacks and greater access to confidential consumer data are major concerns.

II.4 Traditional Role of Central Banks

Over the years, many central banks were established to overcome the challenges posed by the issuance of multiple payment instruments in an uncoordinated manner. In order to restore stability of the monetary system, central banks were exclusively assigned the role of issuing central bank money chiefly banknotes with finality (Carstens, 2018).

In the two-tiered currency system which emerged subsequently consisting of a central bank and private banks, the central bank specialised in supplying banknotes while private banks performed the function of credit creation, providing deposit currencies as part of broad money as well as payment services to the general public. Under this system, the central bank allowed direct access to its accounts only to some private banks (Adrian & Griffoli, 2022; Trucker 2017).

As noted by Adrian and Griffoli (2022), both privately and publicly-issued money have coexisted from time immemorial made possible by the opportunity to redeem private money into safe and liquid public money whether they are notes and coins, or central bank reserves held by banks. They contend that the modern world is characterised by a dual monetary system, involving privately-issued money built upon a foundation of publicly-issued money since privately-issued money by banks, telecom companies, or specialised payment providers represent an efficient means of payment only to the extent it can be redeemed into central bank money.

This public trust and confidence engendered by central banks lie at the heart of functions they perform which include issuance of legal tender currency notes and coins, maintenance of external reserves to safeguard the international value of the local currency, maintenance of monetary stability

and sound financial system, acting as lender of last resort and as a Banker and financial adviser to the government.

II.5 Changing Role of Central Banks

The age of digital money has brought with it additional role for central banks in pursuit of their mandate of maintaining monetary and price stability. Unlike fiat money which combines multiple functions of medium of exchange, store of value and unit of account, various forms of digital currencies tend to separate these functions in principle (Prasad, 2018). This currency debasement which has altered the nature of money is today greatly influencing the changing role of central banks.

The emergence and rise of cryptocurrencies has elicited a range of responses from central banks chiefly due to the risks they pose to the financial system. A payments system which is based on technology and practices designed and managed externally and over which a central bank has no control would naturally demand adjustments to regulatory and supervisory frameworks put in place by central banks (Panetta, 2021). There are also concerns about the declining use of central bank money and its implications for financial stability if decentralised payments systems, such as private cryptocurrencies, dethrone traditional payment systems managed by regulated financial institutions (Prasad, 2018).

As part of this response, a number of central banks are at various stages of issuing their own digital currency. As of September 2022, '105 countries, representing over 95.0 per cent of global GDP, are exploring a CBDC. A new high of 50 countries are in an advanced phase of exploration (development, pilot, or launch)', according to the Atlantic Council. Widely regarded as the first CBDC that covered an entire country, the Sand Dollar was issued by the Central Bank of the Bahamas in October 2020. In April 2020, China became the world's first large economy to test a digital currency while the Central Bank of Nigeria took the lead in Africa when in October 2021, it rolled out its digital currency known as the eNaira.

A number of studies have established common themes in major motivations for central banks issuing their own digital currencies. These include financial inclusion, financial stability, improving monetary policy and payments system (Kosse & Mattei, 2022; Davoodalhosseini, 2021; Bordo & Levin, 2017). The relative importance of each motive for CBDC issuance varies across central banks.

Digital currency issued by a central bank could operate under the same principles as physical currency and when designed and protected by sound regulations, strengthens the payment system in the short run and benefits the economy in the long term (Juhro, 2022) as corroborated by Adrian and Griffoli (2022), the traditional dual-monetary system can be extended to the digital age. They submit that a central bank's currency, backed by strong regulation, supervision, and oversight, will continue to be crucial in anchoring stability and efficiency of the payments system.

In order to meet its intended public policy objectives, it is vital that the adoption and use of a CBDC is at a scale sufficient to justify its investment (Bank of International Settlements, 2021). Accordingly, implementation experiences documented by the Bank for International Settlement suggest three factors which might make CBDC adoption successful namely ability to fulfil unmet user needs which might not currently be met -with respect to consumer or merchant demand- by existing payments products and services; ability to build on existing technology as users may be more willing to accept a CBDC if it does not require all users to buy new devices and ability to achieve network effects as the use of a new service depends both on consumer adoption and merchant acceptance (Bank of International Settlements, 2021).

In addition, based on lessons learned from previous payment implementations, the Bank for International Settlement suggests that countries implementing CBDC may consider pursuing strategies and incentives to improve CBDC adoption. These strategies may include disbursing social benefits and transfers to individuals in CBDC and allowing employees to receive their remuneration in CBDC given that consumers who receive payments in CBDC may be more likely to use CBDC. Another strategy is requiring consumers to pay their taxes in CBDC (Bank of International Settlements, 2021).

II.5.1 CBDC and Monetary Policy

From the perspective of monetary policy and depending on its design, Prasad (2018) argues that CBDCs implemented through electronic wallets would make monetary policy conduct easier. This would be so because interest-bearing CBDC would help transmit the policy interest rate to the rest of the economy. During periods of downturn in economic activity, a CBDC could represent an effective channel of injecting money quickly into an economy (He, 2018).

The Bank for International Settlement is of the view that CBDC will enhance monetary policy implementation if it is designed to offer lower cost to consumers and merchants, relative ease of use, offline payments which come handy during outages and in remote locations without connectivity, a higher level of privacy in comparison to commercial options, instant settlement, flexibility, continuous availability and a high degree of security (Group of Central Banks, 2020).

II.5.2 The eNaira

The eNaira is the digital version of the Nigerian currency. Launched on October 25 2021, the objectives among others include increased financial inclusion and strengthening the payments system. Within a one-year period, it recorded over 700,000 transactions worth about ₦8.00 billion on the platform while ₦3.00 billion had been minted by the apex bank and ₦2.10 billion issued to financial institutions. In addition, the eNaira platform had on-boarded about 1 million customers and successfully registered over 3,305 merchants across the country (Emefiele, 2022). This is a remarkable success for a first mover CBDC.

The second phase of the project which commenced in 2022 is expected to drive financial inclusion by onboarding the unbanked leveraging offline channels as well as revenue collection agencies with a view to increasing and simplifying collections. With a target of 8 million users, the second phase would involve the distribution of targeted welfare schemes via the eNaira (Emefiele, 2022).

II.6 CBDC Adoption and Diffusion of Innovation Theory

Like many technological innovations, the eNaira's target of 8 million users in the second phase of the project would be anchored on the diffusion of Innovation model (Emefiele, 2022). Formulated by Rogers in 1962, the diffusion of innovations theory is one that seeks to explain how new technologies and other innovations spread from introduction to widespread adoption. The adoption of technology, according to Rogers, can be broken into five segments reflecting the fact that the motivation to adopt new technologies among persons differ. These categories are the innovators, who are the first to try the new technology representing not more than 2.5 per cent of the population; early adopters often opinion leaders who embrace the new technology after the innovators and constituting not more than 13.5 percent of the population; early majority comprising 34.0 per cent of the population

and the first sizable segment to adopt the innovation; late majority who tend to be more cautious and requiring hand-holding as they adopt the technology comprising also 34.0 per cent of the population; and the Laggards, the risk averse and conservative, who are slow in embracing new technology representing 16.0 per cent of the population (Rogers, 1995).

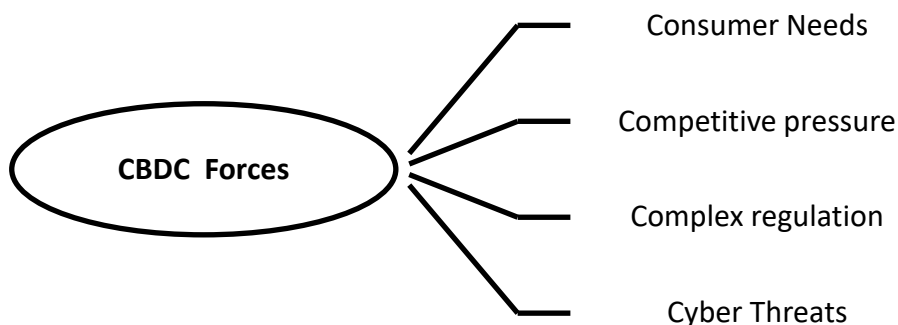
Rogers goes on to propose five elements that influence the spread of new technology namely the innovation itself, adopters, communication channels, time and a social system which includes the society's level of education, arguing that the innovation must be widely adopted in order to be self-sustaining.

III. Discussion

In a bid to discharge its core mandate of monetary and price stability more effectively in the face of the challenge posed by digital money, central banks are increasingly expanding their regulatory role to include direct participation in the payments ecosystem as providers of digital currencies. Although central bank digital currencies are still evolving with only a few cases of full roll outs, it is possible to tease out, based on available literature reviewed in section two of this paper, key forces that shape the implementation of a central bank digital currency.

These forces, illustrated in Figure1, are changing consumer needs, competitive pressure from private digital currencies, complexity of regulation, and cybersecurity threats- the 4 Cs.

Figure 1: **Uwaleke's CBDC** Four Forces Model



Source: Author's conceptualisation.

Changing Consumers' Needs

As the body of literature reviewed brings home, a CBDC needs to generate a critical mass of users- households and firms. To increase the likelihood of adoption, users' needs including low costs, transaction speed, ease of use, and privacy must be accorded priority. These needs tend to be dynamic and vary across countries reflecting different forms of economic activity and diverse payments landscapes (Bank of International Settlements, 2021). As argued by Zamora-Pérez et al. (2022), any new technology should address the subjective perceptions of consumers as superior technology alone does not guarantee wide adoption. One way to achieve this is by increasing the perceived usefulness or ease of use relative to current payment options.

The use of incentives such as a positive opening balance in new accounts as well as massive awareness campaigns are possible strategies to increase adoption but may not be sufficient to counter a lack of trust on the part of the public when users' needs are not met (Arauz & Garrat, 2021; White, 2018). Part of meeting these needs would be through encouraging private innovation in CBDC ecosystems (Group of Central Banks, 2021).

Competitive Pressure

Among financial institutions, which can represent a source of competition to central banks in digital payments provision, a key concern with CBDC introduction is that it might erode the role of commercial banks as financial intermediaries and could result in disintermediation. In this regard, implementing a CBDC has the potential of raising tensions within the private banking sector (Arauz & Garrat, 2021). In order to mitigate the risk of financial intermediation, a CBDC, like the case of eNaira, is designed as non-interest bearing and not meant to be as a savings vehicle.

Generally, for CBDCs not to be perceived as a threat by the market, collaboration between central banks and private companies is very essential. This is one lesson that resonates from the experience of Ecuador which implemented a CBDC project known as Dinero Electronico (DE) from 2014 to 2018. As noted by White (2018), the banking sector's opposition contributed largely to the demise of DE. Therefore, it goes without saying that the support of the private banking sector is crucial to the success of any CBDC initiative. In recognition this, the Bahamas Sand Dollar development team incorporated a CBDC solution where financial intermediaries can introduce retail CBDC-based financial products and services (Kim & Mohan, 2020).

With introduction of CBDCs, Central banks enter a fiercely competitive market in view of the plethora of electronic payment systems already available to users such as electronic transfers and electronic cards. In October 2022, the Central Bank of Nigeria introduced a national domestic card which is expected to operate alongside other private players such as Visa and Mastercard that dominate the card payment market in Nigeria. The impact of this, together with the eNaira, on the payments system will depend on the adoption rate and the operating model between the central bank of Nigeria and the private players.

Indeed, CBDCs could function as payment mechanisms which enhance the overall payments system in the economy without necessarily crowding out private innovations (Prasad, 2018). In particular, in order to cope with competitive pressure from private cryptocurrencies, central banks have been advised to strive to run effective monetary policy which seek to make fiat currencies a more stable unit of account (He, 2018).

Complex Regulation

Closely connected to competitive pressure from private digital currencies is the nature and adequacy of market regulation. Complex and uncoordinated regulation may pose a threat to the success of a CBDC. As earlier noted, unlike fiat money which performs three primary functions namely medium of exchange, unit of account and store of value, cryptocurrencies tend to regiment these functions resulting in gaps in regulatory oversight and fragmented regulations in some countries.

In the United States of America for example, the Securities and Exchange Commission (SEC) has the authority to oversee initial coin offerings (ICOs) since they typically involve the offer and sale of securities; the Commodities Futures Trading Commission (CFTC) considers virtual currencies to be commodities subject to oversight under its authority while the Internal Revenue Service (IRS) treats virtual currencies as property subject to capital gains tax. So, unlike South Korea which passed the world's first comprehensive digital currency law- Specific Financial Information Act- in March 2020, there is no direct and comprehensive regulation over virtual currencies in the United States as the regulatory framework appears fragmented and overlapping in relation to digital currencies (Dahlberg, 2019).

In Nigeria, both the Central Bank and the Securities and Exchange Commission lay claims to crypto asset jurisdiction. In February 2021, the CBN

issued a circular prohibiting financial institutions from transacting in cryptocurrencies or facilitating payments for cryptocurrency Exchanges. Prior to the 2021 CBN circular, the SEC had on 14th September 2020, released a 'statement on digital assets and their classification and treatment' in which the Commission said it would regulate all digital assets that exhibit full characteristics of investments as defined in the Investments and Securities Act 2007.

In this regard, the CBN and the SEC are collaborating through an Inter-Agency committee on virtual currency saddled with the responsibility of coming up with a comprehensive regulatory framework for cryptocurrencies (Uwaleke, 2022). Given that the nature of some virtual currencies make it difficult to subject them to national rules and regulations (Prasad 2018), the threat to CBDC is minimised if digital currencies' regulatory efforts are coordinated and harmonised across countries.

Cybersecurity Threats

The introduction of a CBDC is usually geared towards enhancing the existing payment infrastructure. But by so doing, the attack surface of new networks and infrastructures is increased. This can potentially amplify the scope and scale of many of the security and privacy threats that already exist in today's financial system given that an attack or disruption of a CBDC arrangement may pose broader risks to financial markets and central banks (Fanti et al., 2022; Hansen & Delak, 2022).

Generally, the security considerations for a CBDC do not differ from those associated with other electronic payment systems as attackers will continue to use phishing attacks and malware to obtain credentials or private keys. In order to mitigate this risk, a central bank issuing a digital currency must put in place a robust information security program (Hansen & Delak, 2022). As noted by Fanti et al. (2022), there are many design variants for CBDCs, ranging from centralised databases to distributed ledgers to token-based systems. Regardless of the design, cybersecurity and privacy risks must be accorded priority.

Under the distributed ledger technology (DLT) used for the eNaira, third parties, such as financial and non-financial institutions, are required as validators of transactions which introduces new roles for third parties in central bank money operations. The major risk here is that the security guarantees of the ledger would depend on the integrity of third-party validators, over which

the central bank may not have direct control. Fanti et al. (2022) suggest that this risk can be mitigated through regulatory mechanisms such as auditing requirements and stringent breach disclosure requirements.

Cybersecurity risk is amplified by the absence of cross-border regulation, interoperability, and standard-setting (Fanti et al., 2022). Cooperation among central banks through knowledge sharing and promoting standard-setting in the international context, could improve central banks' ability to respond to cyber-attacks (Doerr et al., 2022).

IV. Conclusions

The digital age has ushered in new realities for central banks. Through parceling out the core functions of money in an economy, digital currencies are changing the roles of central banks. If it must meet its desired public policy objectives in a fast-changing payments landscape, a central bank would need to implement a CBDC project in order to augment private sector efforts, provide diversity in the digital payment ecosystem and enhance the payments system in general. A CBDC is thus essential for orderly conduct of payments in a digital world. However, introduction of a CBDC must be approached in a manner that does not diminish the private sector's role in retail payments and financial intermediation.

To enhance their chances of success and maintain trust in their digital currency, central banks should continuously innovate and rise to the challenge of the key forces likely to shape the path of any CBDC including changing consumer needs, competitive pressure from private digital currencies, complex regulations and cybersecurity threats.

V. Policy Recommendations

Based on the conclusions reached, the following policy recommendations are made:

- i. A central bank should continue to fine-tune and upgrade a CBDC after it is introduced;
- ii. Regulation of digital currencies should be well coordinated and harmonised to prevent regulatory arbitrage and any unfair competitive advantage private crypto currencies may derive from fragmented regulation;

- iii. In the implementation of a CBDC project, Central banks should endeavor to minimise their impact on financial intermediation and credit provision including through designing the CBDC as principally a medium of exchange as opposed to a store of value in the digital ecosystem;
- iv. A CBDC is likely to be successful if it continues to build trust in central banks. Given the importance of continuous multi-level cooperation in the implementation of a CBDC project, Central banks will have to work closely with private operators – financial institutions, Fintech groups, telecom companies, merchants and consumers – to understand their needs and how to meet them for the purpose of enhancing the value of the CBDC. Close partnership with private firms is required to successfully distribute CBDCs and generally extend the frontiers of technology;
- v. Given that private cryptocurrencies, such as Bitcoins, are not functional as a means of payment, but rely on the connection to standard means of payments and trading apps that link users to conventional bank accounts, central banks should ensure that the relationship between cryptocurrencies and central bank currencies is not parasitic in order to safeguard the payment system;
- vi. In order to optimise the use of CBDCs in cross border transactions and mitigate interoperability risk in the future of money, central banks should not just focus on their digital currencies but cooperate with each other through knowledge sharing and the development of international standards for the regulation of digital currencies. The adoption of different CBDC models by Central Banks across the world present a compelling case for international standard setting; and
- vii. Fiscal authorities can help improve CBDC adoption by providing certain incentives such as rebates on Value Added Tax, as well as requiring that a percentage of government workers' remuneration be made via CBDC.

References

- Adrian, T., & Mancini-Griffoli, T. (2021). Public and private money can coexist in the digital age. <https://www.imf.org/Articles>.
- Atlantic Council. (2022). *Central bank digital currency tracker*. <https://www.atlanticcouncil.org/cbdctracker>.
- Arauz, A., & Garratt, R. (2021). Dinero Electrónico: The rise and fall of Ecuador's central bank digital currency. *Latin American Journal of Central Banking*, 2(2), 100030.
- Bank for International Settlement. (2021). CBDCs: An opportunity for the monetary system. Annual Economic Report, Chapter 3, June.
- Bordo, M., & T. Levin. (2017). *Central bank digital currency and the future of monetary policy*. NBER Working Paper Series, N o 23711.
- Carstens, A. (2018, February 6). *Money in the digital age: What role for central banks?* [BIS lecture]. Goethe University Frankfurt.
- Central Bank of Nigeria. (2016). *Education in economics*. Series No 2. A publication of Research Department.
- Central Bank of Nigeria. (2021). *Understanding monetary policy*. Series No. 2.
- Dahlberg, T. (2019). What blockchain developers and users expect from virtual currency regulations: A survey study. *Information Polity*, 24(4), 453-467.
- Davoodalhosseini, S. M. (2022). Central bank digital currency and monetary policy. *Journal of Economic Dynamics and Control*, 142, 104150.
- Doerr, S., Gambacorta, L., Leach, T., Legros, B., & Whyte, D. (2022). *Cyber risk in central banking*. BIS Working Papers No 1039 September. <https://www.bis.org/publ/work1039.pdf>.
- Emefiele, G. I. (2022). Leveraging Innovation for Inclusive Growth and Development: The eNaira Advantage. Speech on the occasion of the first anniversary of the eNaira, October 25.
- Fanti, G., Lipsky, J., & Moehr, O. (2022). Central bankers' new cybersecurity challenge. *Finance & Development*, 59(003).
- Glyn, D. (2016). *A history of money*. University of Wakes Press.
- Group of Central Banks. (2020). Central bank digital currencies: Foundational principles and core features.
- Group of Central Banks. (2021) Central bank digital currencies: Financial stability implications.
- Bozma, G., & Akdağ, M. (2021). An Evaluation of Central Bank Digital Currency. *The Journal of International Scientific Researches*, 6(3), 271-276.
- Hansen, T., & Delak, K. (2022). Security considerations for a central bank digital currency. Fed Notes. <https://www.federalreserve.gov/econres/notes/feds-notes>.

- He, D. (2018). Money, transformed monetary policy: In the digital age. IMF Library.
- Jantsankhorloo, A. (2019). Central Banking in the digital age: A new money bank of Mongolia. <https://www.mongolbank.mn/documents>.
- Juhro, S. M., (2022). Central bank policy mix: issues, challenges, and policy responses. In P. Warjiyo & S. M. Juhro (Eds.), *central bank policy mix: issues, challenges, and policy responses* (pp. 17-26). Springer.
- Kim, J., & Mohan, V. (2020). Three lessons from project sand dollar. Official Monetary and Financial Institutions Forum. <https://www.omfif.org/2020/09/three-lessons-from-project-sand-dollar/>.
- Kosse, A., & Mattei, I. (2022). *Gaining momentum – Results of the 2021 BIS survey on central bank digital currencies*. BIS Papers, No 125, Bank for international Settlements, Basel.
- Lengsfeld, J. (2019). Digital era framework. <https://joernlensfeld.com>
- Panetta, F. (2021, December 10). *The present and future of money in the digital age*. [Speech]. European Central Bank. <https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211210~09b6887f8b.en.html>.
- Prasad, E. (2018). Central banking in a digital age: Stock-taking and preliminary thoughts. Hutchins Center on fiscal and Monetary Policy Brookings.
- Rogers, E. (1995). *Diffusion of innovations*. (4th ed.). Free Press.
- Tucker P. (2017). The political economy of central banking in the digital age. *SUERF Policy Note and Briefs*, 13. https://www.hks.harvard.edu/centers/mrcbg/publications/awp/tucker_suerf
- Uwaleke, U. (2022). 10 Ps of the Nigerian capital market. GreenRay Publications.
- White, L. (2018). The world's first central bank electronic money has come-and gone: Ecuador, 2014-2018.
- Zamora-Pérez, A., Coschignano, E., & Barreiro, L. (2022). Ensuring adoption of central bank digital currencies—An easy task or a Gordian knot? *ECB Occasional Paper*, (2022/307).