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Nigeria's eNaira, One Year After

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Nigeria's eNaira, One Year After

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ABSTRACT: This paper reflects on the first year of the eNaira—the first CBDC in Africa. Despite the laudable undisrupted operation for the first full year, the CBDC project has not yet moved beyond the initial wave of limited adoption. Network effects suggest the initial low adoption spell will require a coordinated policy drive to break it. The eNaira's potential in financial inclusion requires a strategy to set the right relationship with mobile money, given the former's potential to either complement or substitute the latter. Cost savings from integrating CBDC—as a bridge vehicle—in the remittance process may also be substantial.

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WORKING PAPERS

NIGERIA'S ENAIRA, ONE YEAR AFTER

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Introduction

In recent years, CBDCs have become one of the fanciest concepts among central bankers reflecting the global shifts towards cashless economies and trend expansion of digital assets—which ramped up interests in digital medium of exchange (see Box 1). For Sub-Saharan Africa (SSA) countries, in particular, CBDCs have been deemed to have especially powerful potential given the region's financial inclusion and remittance challenges (see Annex I) and its history of technology-driven leapfrogging. Amid these interests, in October 2021, Nigeria's became the second country in the world—only after the Bahamas[1] [2]—to launch a fully public CBDC (eNaira).

The motivation of the eNaira launch, according to the central bank of Nigeria (CBN), are as follows:

- *Increase in financial inclusion.* Initially, the eNaira wallet was provided only to people with bank accounts, but coverage was expanded in August 2022 to anyone with a mobile phone even if they did not have a bank account. Many people in Nigeria do not have bank accounts (38 million people; 36 percent of the adult population). Yet, cellphone penetration in Africa is among the highest in the world. Nigeria reckoned that providing eNaira access to those with phones and no bank accounts could increase financial inclusion and facilitate more direct and effective implementation of social transfers programs.

- *Facilitation of remittances.* Nigeria is among the key remittance destinations in sub-Saharan Africa, with remittance receipts amounting to $24 billion in 2019 (5.3% as a percent of GDP). Remittances are typically made through international money transfer operators (IMTOs) such as MoneyGram or Western Union. These money transmitters charge between 7.8% and 8.7% per transaction (World Bank, Remittance Prices Worldwide). By using frictionless digital money, the Nigerian government sought to reduce remittance transfer costs, making it easier for the Nigerian diaspora to remit funds to Nigeria.

- *Reduced informality.* Nigeria has a large informal economy, with transactions and employment equivalent, respectively, to over half of GDP and 80 percent of employment. The eNaira is account-based, and transactions are in principle fully traceable, unlike for example token-based crypto asset transactions. Once the eNaira becomes more widespread and embedded into the economy, it may bring greater transparency to informal payments and strengthen the tax base.

[1] Some countries and regions (e.g., China) had rolled out CBDCs earlier but as pilots—hence granting access only to a subset of their citizens. According to Atlantic Council's CBDC tracker, more than 100 countries are currently exploring CBDC in various phases (development, pilot, or launch).

[2] Central Bank of Bahamas Governor John Roll has highlighted importance of a merchant network, interoperability, participation by banks, and user education as key lessoned from the first year of Sand Dollar experiment. (https://cdn.centralbankbahamas.com/documents/2022-11-10-16-42-59-European-Commission-Presentation-on-Sand-Dollar-Experience-20221107DG1.pdf)

While being SSA's largest economy, Nigeria has had only a limited degree of success in its financial inclusion drive. It also lags peers in mobile money penetration—with a fragmented industry landscape[3]—which increases costs of interoperability. At the same time, it has managed to foster a dynamic FinTech sector, which has been leading digitalization of its monetary system through various initiatives[4]. Nigeria also has a pressing need for encouraging remittance flows—given its large size of emigrant workforce and prolonged balance of payment pressures[5]. All of these factors seemed to have motivated Nigeria to become the earliest mover in the global CBDC movement, which had largely been in exploratory stages. Hence, the degree of Nigeria's success in CBDC will critically affect other central banks' decisions on whether (and how) to introduce their own CBDCs.

This paper takes stock of the first year of Nigeria's eNaira launch. This paper is organized as follows. The next section presents a brief overview of the eNaira focusing on its design features. The subsequent section takes stock of the first year focusing on the slow adoption of the eNaira's so far. The following section aims to answer two questions: (1) why the eNaira adoption has been slow; and (2) what key points of consideration are for a strategy for its breakthrough.

[3] In Kenya, the market is decidedly dominated by Safaricom's M-Pesa. In Ghana, MTN is the dominant industry player. In Nigeria, there are 21 mobile money operators and the market share of the current leader Paga (51 percent) does not reach a position of distinctive dominance with the rest of the market split into various other players: OPay 21.9 percent, MTM MoMo 15.6 percent, KongaPay 6.3 percent, PalmPay 3.1 percent (https://www.theasianbanker.com/updates-and-articles/opay-targets-unbanked-across-africa-backed-by-softbank).

[4] See Economist (2021).

[5] See 2021 2022 Nigeria Article IV Consultation Staff Reports.

Box 1. Cashless Trend, Digital Assets, and Interests in CBDC

In recent years, CBDC has become one of the fanciest words not only among the central bankers, but also in the global fintech communities. There are good reasons. First, the ubiquitous presence of mobile phones and widely penetrated electronic payments have made some economies effectively cashless (e.g., Sweden[6]). In some, this trend has gone so far-reaching that there is no guaranteed acceptance for cash at retail levels[7] anymore. COVID-19 pandemic has aggravated this trend with some retail outlets (e.g., Target in U.S.[8]) refusing to accept cash, citing concerns on contact-led infections. The cashless trend could, however, aggravate socioeconomic inequality as poor people are less likely to be financially included—a necessary condition to have access to privately-provided medium of electronic payment such as a debit card. Against this backdrop, central banks began to look into the potential of CBDC as a digital fiat currency, which fits the cashless trend and fill the financial inclusion vacuum caused by it.

Second, recent years have seen an explosive growth of the digital assets. This was fueled by innovative blockchain technologies, desire for censorship-free financial transactions, and also some bandwagon effects. According to MAS Managing Director Ravi Menon[9], digital asset universes (e.g., Ethereum ecosystem) have a great potential for finance and beyond. Through tokenization, for example, it enables monetization of assets (e.g., trademark or intellectual property), fractionalization of them (e.g., selling a fraction of a real estate project), and decentralized and seamless trading of them (including for cross-border payment). However, a digital asset ecosystem needs a tokenized medium of exchange to facilitate transactions. And this has led to a dramatic rise of stablecoins. However, recent collapse of one the most influential non-asset-backed (or algorithmic) stablecoins (i.e., Terra)[10], has illustrated the clear danger of unregulated stablecoins, which could have financial stability ramifications, even globally. This phenomenon has also opened up a new possibility for retail CBDCs to be used as stablecoin substitutes in the digital asset universe.

[6] Sweden is expected to become the world's first cashless society in as early as 2023 (See https://interestingengineering.com/innovation/sweden-how-to-live-in-the-worlds-first-cashless-society).

[7] If very few customers pay in cash, there is little need for preparing changes. This makes the overhead cost for cash transactions (e.g., trip to banks) more expensive and increase the incentives for merchants to go 100 percent electronic in transaction with customers.

[8] See "Know Before You Go|Target" (https://www.targetcenter.com/plan_your_visit/know-before-you-go).

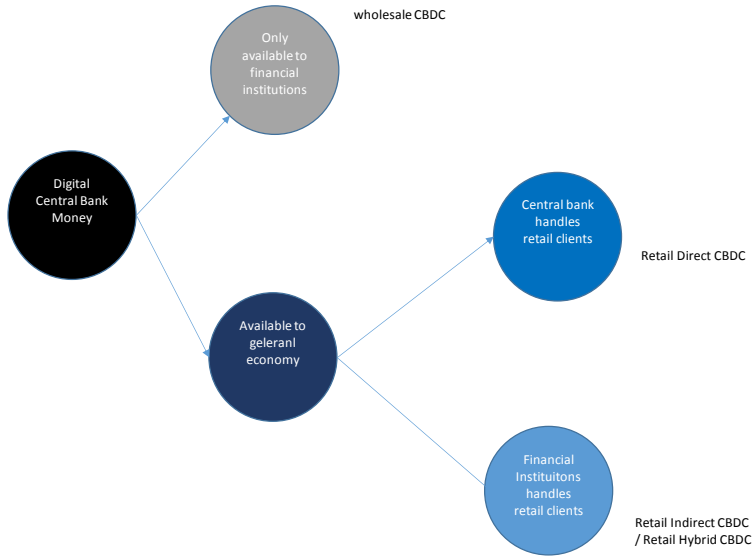
[9] See Ravi Manon (2022).

[10] See Clement (2021), Chaundhary and Viswanath-Natraj (2022), Vanian (2021).

eNaira Overview: Design Features

On October 25, 2021, the CBN has officially launched the eNaira—Africa's first CBDC. The intensive process of preparation dates back to 2017—when the CBN initiated an internal study and external consultation, which was followed by a proof of concept in a sandbox environment. Just like physical cash, the eNaira is a liability of the CBN. It uses a blockchain technology, stored in digital wallets, and can be used for payment transactions. As a claim on CBN, like physical cash, the eNaira may be owned and used by both wholesale (i.e., banks) and retail (i.e., merchants and individuals) clients using electronic wallets.

Figure 1. CBDC Taxonomy



Source: Author's elaboration based on Auer and Boehm (2020).

While all eNaira transactions are handled in real time and recorded by a CBN system (albeit using a distributed ledger (DLT)[11]), transactions with retail CBDC clients (e.g., exchanging CBDC with retail clients' cash or deposit holdings) are all handled by financial institutions, mainly banks[12]—with CBN directly transacting only with them. In this sense, the retail end of the eNaira's system may be seen as an intermediated or a two-tiered system. According to BIS's taxonomy (Auer and Boehme, 2020), alternative model choices include (1) a single-tier retail CBDC, where central banks directly onboard retail clients and handle all retail payments; (2) an indirect CBDC, where CBDC is issued only to banks, which then issue indirect CBDC (ICBDC) to their clients—with the latter

[11] According to BIS "DLT refers to processes and related technologies that enable nodes in a network (or arrangement) to securely propose, validate and record state changes (or updates) to a synchronized ledger that is distributed across the network's nodes. In the context of payment, clearing, and settlement, DLT enables entities, through the use of established procedures and protocols, to carry out transactions without necessarily relying on a central authority to maintain a single "golden copy" of the ledger." (https://www.bis.org/cpmi/publ/d157.pdf).

[12] Nonbank providers of mobile money may also handle distribution and withdrawal of eNaira through mobile money to eNaira exchanges. They may in principle also conduct onsite onboarding for clients without accounts after relevant KYC checks (e.g., after collecting photo and identify declaration for tier 1 eNaira wallets).

(ICBDC)[13] fully backed by the former (CBDC), and (3) an intermediated or two-tiered CBDC where central bank issues CBDC mainly (or only to) banks (in exchange for reserve deposits), which then handles CBDC transaction with retail clients (e.g., exchange retail deposits to CBDC, similar to the case of meeting cash withdrawal request at ATM or over the counter)—along with nonbank payment service providers.

eNaira transactions are executed using a proprietary software platform called "Digital Currency Management System (DCMS)" developed by Bitt Inc., which uses Hyperledger Fabric as the underlying transaction network or ledger. The DCMS provides a variety of wallets, whose capabilities are distinguished based on the users' differentiated roles in the CBDC system. For example, certain types of financial institution wallets are able to request new issuance transactions from the central bank, while other types of them are able to execute deposit or cash to CBDC exchange transactions for retail and enterprise clients. As transactions are executed through the applications or APIs provided through the DCMS, the DCMS Numa[14] queues and submits the transactions to Hyperledger Fabric, the underlying transaction network, to be settled in real time. At this point, the Hyperledger Fabric nodes verify and append the transactions to the ledger in the manner described in Appendix I.

The eNaira uses Hyperledger Fabric[15] as its technological backbone[16]. As a distributed ledger, it allows all participating nodes[17] to keep all record of CBDC transaction through the entire history (as a blockchain), take turns to lead the assembling of a block (i.e., record of all transactions occurring during a certain time frame),

[13] This is not very different from conventional bank account-based retail payment system—called automated clearing house network (ACH) system—except for deferred availability of fund for payees and deferred settlement inherent in ACH. CBDC has a potential to enable real time gross settlement and also immediate fund availability for payees for even for very small payments—therefore significantly improving efficiency and safety of payment and settlement. Recently, technological innovation has expedited progress in so called fast retail payment systems, but most such systems rely on deferred batch settlement—thus subjecting payment service providers (PSPs) to credit risks (see BIS, How do fast payment systems work).

[14] According to Wikepedia "Non-uniform memory access (NUMA) is a computer memory design used in multiprocessing where the memory access time depends on the memory location relative to the processor". In the computer industry, Uniform Memory Access (UMA) and NUMA are two types of commonly adopted memory architecture designs. UMA allows equal access times to all memory regions for all processors but it faces scalability constraints. NUMA design significantly improves scalability by linking each processor to its own local memory and then connecting all such processors and their local memories to a common network, so that a processor can access both the local and remote memories (Manchanda and Anand: http://www.cs.nyu.edu/~lerner/spring10/projects/NUMA.pdf).

[15] According to IBM, "Hyperledger Fabric, an open source project from the Linux Foundation, is the modular blockchain framework and de facto standard for enterprise blockchain platforms" (https://www.ibm.com/topics/hyperledger).

[16] For official documentation diagram of the technology see https://hyperledger-fabric.readthedocs.io/en/release-2.5/txflow.html.

[17] In computer science, computers participating in a network of computers are called "nodes". In the context of crypto and blockchain, a node is one of the computers that run the blockchain's software to validate and store the complete history of transactions on the network.

independently verify the block broadcasted by the nod in charge at certain point in time, and participate in collective validation of the block via a super-majority voting[1819] .

- Key advantage of a distributed ledger technology is its relative strength against risks of hacking—to which traditional host-client computer models are becoming more and more vulnerable.

- Distributed ledgers can mitigate against single point of failure risk by virtue of having multiple "operators" or "hosts" in geographically dispersed locations.

- However, a distributed ledger technology also has technical limitation in the speed of processing and sealing a block[20]—without which payment does not become final. So far, the eNaira system has not faced a latency problem. However, given Nigeria's population size and the density of transactions that may eventually go into the eNaira system, there may be a need to carefully adjust the eNaira's system architecture going forward.

eNaira uses an account-based blockchain technology[21], which makes transactions traceable to identified individuals or businesses if needed. Retail eNaira wallets are subject to both transaction and balance ceilings (Table 1)—based on a tiered KYC system—the prevailing AML/CFT backbone for Nigeria since 2013[22]. This mitigates both the risk of deposit disintermediation and AML/CFT risks arising from CBDC. However, existing AML/CFT regulatory framework may not be sufficient to completely address new risks stemming from CBDC[23] and CBN should vigilantly monitor these.

[18] This way of consensus mechanism can be considered Byzantine Fault Proof Tolerant (BFT)—which applies in distributed systems whereby the system can maintain integrity provided the majority of nodes are honest. A public blockchain with many and anonymous nodes utilizes proof of work (Bitcoin) or a poof of stake (Ethereum) to achieve Byzantine Fault Tolerance in a decentralized manner.

[19] However, unlike a public block chain, Hyperledger Fabric is a permissioned DLT, where powers and permissions granted to different nodes can be customized (e.g., certain nodes may be given a power to manage permissions). While the access can be expanded to non-CBN nodes, currently all nodes in the eNaira system are computers in various CBN locations.

[20] Despite its benefits in terms of resilience, redundancy, and security, distributed ledger technology may lead to undesirable decentralization in system governance (See Bank of England (2023)). However, Hyper Ledger Fabric as a permissioned DLT, is less prone to be subject to risks stemming from uncontrolled decentralization. At present, all permissioned nodes of the eNaira system are CBN computers—which makes it very similar to a centrally-managed distributed database.

[21] According to Crypto API, "The account-based model is a balance management system that works in a similar way to the traditional bank account." (https://cryptoapis.io/blog/7-utxo-and-account-based-blockchains).

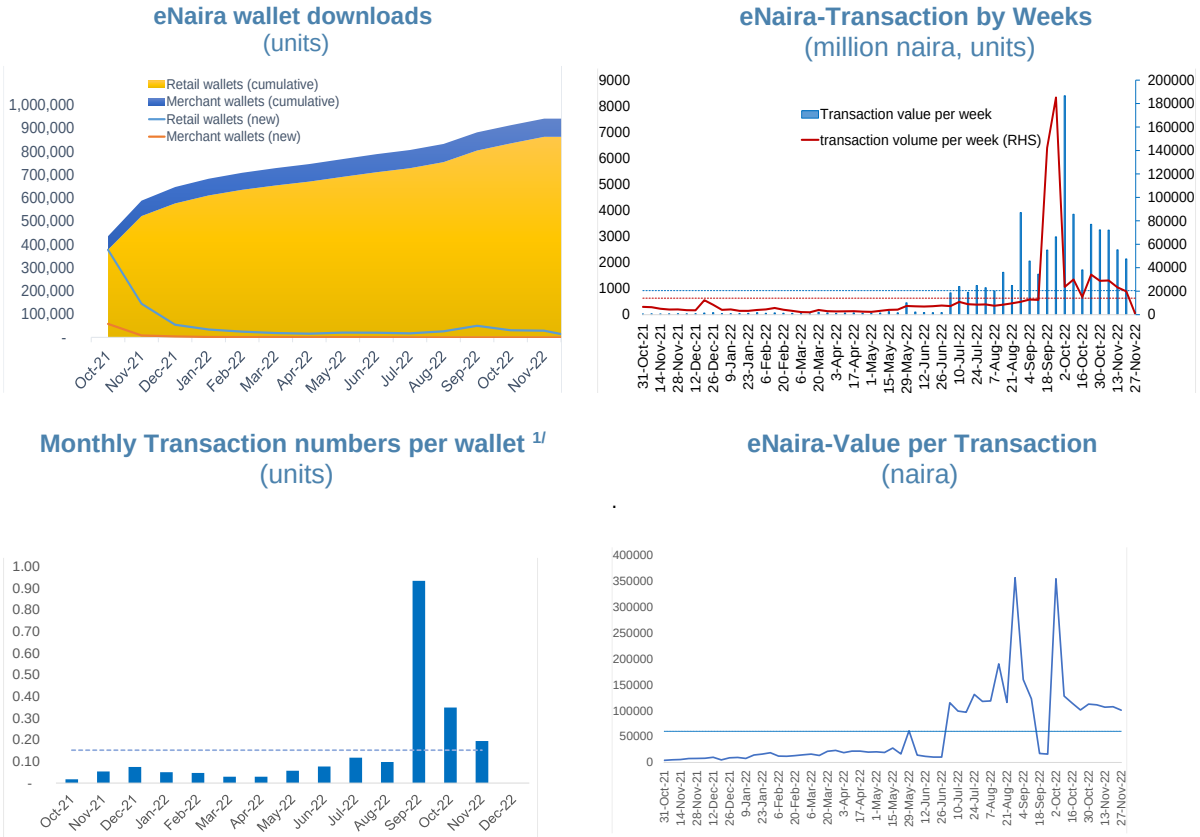
[22] See CBN's circular on introduction of 3 tier KYC (https://www.cbn.gov.ng/out/2013/ccd/3%20tiered%20kyc%20requirements.pdf).

[23] For example, merchant wallets are not subject to transaction or balance ceilings, which may present some risks in the absence of adequate mitigants. However strict AML Compliance rules apply for collecting and verifying business information prior to obtaining a merchant wallet. In addition, merchant eNaira balances are auto-converted to the linked bank account at the end of every day.

Table 1. eNaira: Tiered Wallet System				
Tier	Client category	Requirement to open eNaira wallet	Identity test	Illustrative Limits
0	Retail (including people without bank account)	Phone number	No identify information required except for phone number	. Daily transaction limit (N20,000) . Balance limit (N120,000)
1	Retail (including people without bank account)	Phone number (national id number verified)	Basic identity information (e.g., photo, name, date of birth); no evidence required; no verification required	. Daily transaction limit (N50,000) . Balance limit (N300,000)
2	Retail (people with bank account)	Bank verification number (BVN)	Basic identity information (e.g., photo, name, date of birth); evidence required for submitted information; customer to be verified through official databases	Daily transaction limit (N200,000) Balance limit (N500,000)
3	Retail (people with bank account)	Bank verification number (BVN)	Full identify information and evidence (including proof of address and physical presence in the address) in pursuant to CBN's AML/CFT Regulation 2009. Risk-based verification done.	Daily transaction limit (N1,000,000) Balance limit (N5,000,000)
Merchant		Existing bank account, TIN, BVN of MD/CEO, email address, business certificate	Full KYC requirement in pursuant to CBN's AML/CFT Regulation 2009.	No limit

Year One: Experience and Achievement

Figure 2. eNaira, One Year After



Sources: CBN and IMF staff estimates.
1/ Number of transactions per month/number of downloaded wallets.

In this section, we take stock of how the eNaira is faring one year after its launch. Despite some initial glitches[24], no major risk factors—e.g., a large-scale cybersecurity event—have materialized, allowing CBN to maintain 24/7 operation, without a single outage for the full year[25]. This must have surely helped consolidating user confidence on the product. However, the take-up of the eNaira by households and merchants has been slow.

- *Wallet downloads*: The retail wallet downloads saw a few weeks of initial surge before tapering off. More specially, it only took 25 days for the number of downloaded wallets to reach 500,000 units—but going from there to 600,000 units took another 63 days; and to 700,000 units yet another 143 days. As of end-November 2021, the total number of retails eNaira wallets amounted to about 860,000. This is

[24] https://coincu.com/news/dead-on-arrival-how-the-nigerian-enaira-has-fared-since-launch-1780201/

[25] This cannot be taken for granted given experience of other CBDCs that encountered months-long outage (e.g., ECCU's Dcash).

just 0.8 percent of Nigeria's active bank accounts. Merchant wallet download has reached about 100,000 in end-June, which is about one eleventh of the number of merchants with Point-of-Sales (POS) terminals—which enables credit or debit card payments.

- *Transactions:* Most wallets appear to remain inactive except for a limited window of weeks of activity surge. The average number of eNaira transactions since its inception amounts to about 14,000 per week—only 1.5 percent of the number of wallets out there. This means that 98.5 percent of wallets, for any given week, have not been used even once. The average value of eNaira transaction has been 923 million naira per week—0.0018 percent of the average amount of M3 during this period. The average value per one transaction has been 60,000 naira.

As indicated by the levels of wallet downloads and transactions, the public adoption of the eNaira thus far has been disappointingly low. However, it would be still too early to judge the fate of the eNaira project:

- First, the slowness in eNaira take-up is not an unexpected outcome given CBN's choice of a 'phased approach'— initially granting access only to customers with bank accounts and restricting eNaira transactions to onshore uses only. Thus, the eNaira has, until recently, not presented tangible benefits to most of its wallet holders—given limited acceptance (e.g., low level of adoption by merchants and other retail customers) and availability (for these customers) of alternative means of payment (e.g., debit card, mobile banking apps)—which are more readily accepted. In fact, the total number of eNaira transactions since the inception (around 802,000) is less than the number of eNaira wallets—implying that bulk of the current wallet holders have not used their wallets more than once after opening their wallets.
- Second, even though the eNaira is a legal tender—its universal acceptance cannot be imposed on the public[26]. And this makes the eNaira a network externality product—whose value increases with the size of the network. Like any network products with similar traits (e.g., credit card), breaking the initial low adoption equilibrium requires mix of clever strategies and luck. eNaira would also need to compete with the far-more established incumbent networks (e.g., mobile money)—which provides broadly the same service at the retail level[27] [28]. Weakness in public's trust on Nigeria's monetary system and the eNaira's technological reliability is another important barrier that needs to be tackled[29].

[26] eNaira's legal tender status means that it relinquished debt if tended. This however does not imply a legal obligation to accept eNaira under any circumstances given the technical limitation on acceptability by the counterpart (e.g., direct or indirect access to eNaira network).

[27] IMF (2018) observes that CBDC's user appeal, as digital money, will likely be limited in advanced economies due to availability of existing private digital money with similar or superior traits (e.g., bank deposits with fast payment). However, it also argues that in jurisdictions with limited banking penetration and unreliable settlement platforms, CBDC may gain more user attractiveness—particularly if private digital money fully secured by cash such as mobile money does not exist.

[28] Technological reliability and public trust are also important preconditions for public adoption. For the former., eNaira has passed the initial test by maintaining operational continuity in the first year—although tests will continue with increases in the network size. For the latter, continued public education will be key.

[29] These elements are particularly pertinent for eNaira to counter the substitution pressures into foreign fiat currencies and crypto assets (see IMF 2023 for details) in the context of Nigera's high inflation and absence of alternative means of inflation hedge.

What is CBN doing to move the eNaira project ahead? While digesting takeaways from the initial phase, CBN has moved to phase 2 of the project, expanding the eNaira coverage to (1) people without bank account (but with mobile phones and KYC) and (2) those without internet access (through USSD technology[30]). People without bank accounts may open an eNaira wallet by providing their national ID number (NIN), and load eNaira balance through cash-in services provided by the agency banking network, moving mobile money, or receiving the eNaira from a third party. CBN has intensified the eNaira public adoption campaign, by actively promoting its usage by (1) encouraging major supermarkets and hotels to participate in its merchant network, (2) providing stipend to CBN staff through the eNaira, and (3) hosting developer Heckathons for promotion and discovery of eNaira use cases. While the expansion of the usage of the eNaira[31] for remittances are unlikely to happen in the near term, consideration is being given to its modalities.

[30] Unstructured Supplementary Service Data (USSD) allows users without a smartphone or data/internet connection to use mobile banking through simple codes (numbers and special characters). The USSD based mobile banking network is well established in the SSA region.

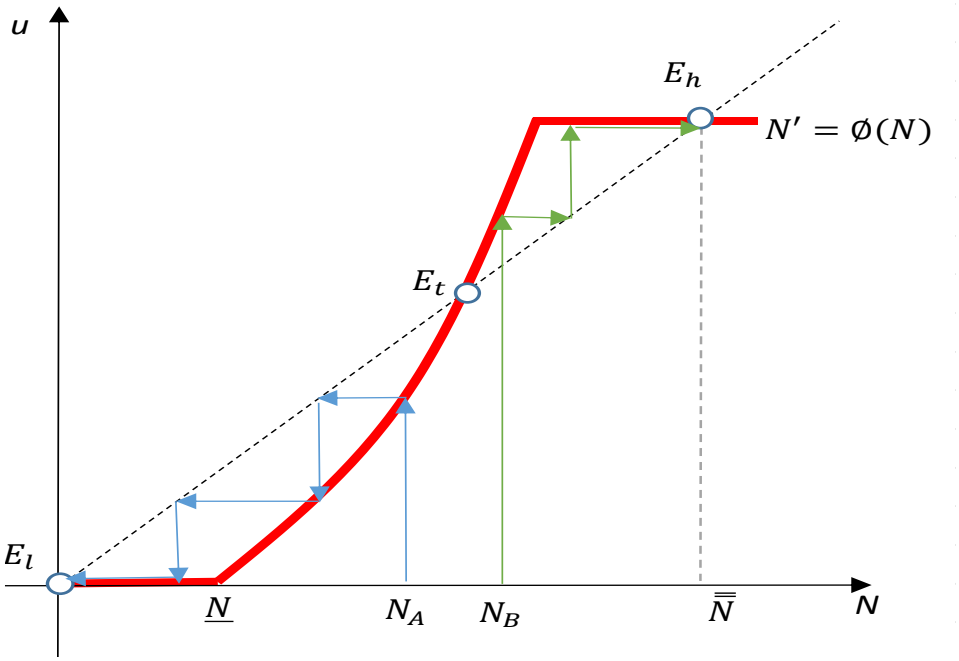
[31] Although its use for remittance was one of the main motivation of eNaira, this has not yet happened with persistent wide parallel market spread being the key impediment (see section five for details).

Box 2. eNaira as a Network Product

The eNaira can be seen as a network externality product—whose value increases with the size of the network. Like any products with similar traits (e.g., credit cards), breaking the initial low adoption equilibrium could prove difficult.

Figure 3 illustrates a tipping point and high and low adoption equilibria in a highly stylized network model of CBDC (see Annex II). The graphics show that there could be both high adoption equilibrium (E_h). and low adoption equilibrium (E_l) for the eNaira. Where the eNaira project will eventually arrive will hinge on whether the mass adoption campaign can push the overall size of the adopters (N) through the tipping point (E_t). The evolution of N is path dependent and thus hinges on the starting point. If the starting point $N_A < N_t^*$, the N corresponding to the tipping point E_t then the transition in subsequent states (represented by blue arrows in the chart) will drive the equilibrium network size N to the low adoption equilibrium E_l. On the contrary, if the starting point $N_B > N_t^*$, then the subsequent path of N will follow an upward spiral (represented by green arrows in the chart) until it converges to a high adoption equilibrium E_h.

Figure 3. Tipping Point, High and Low Equilibria 1/



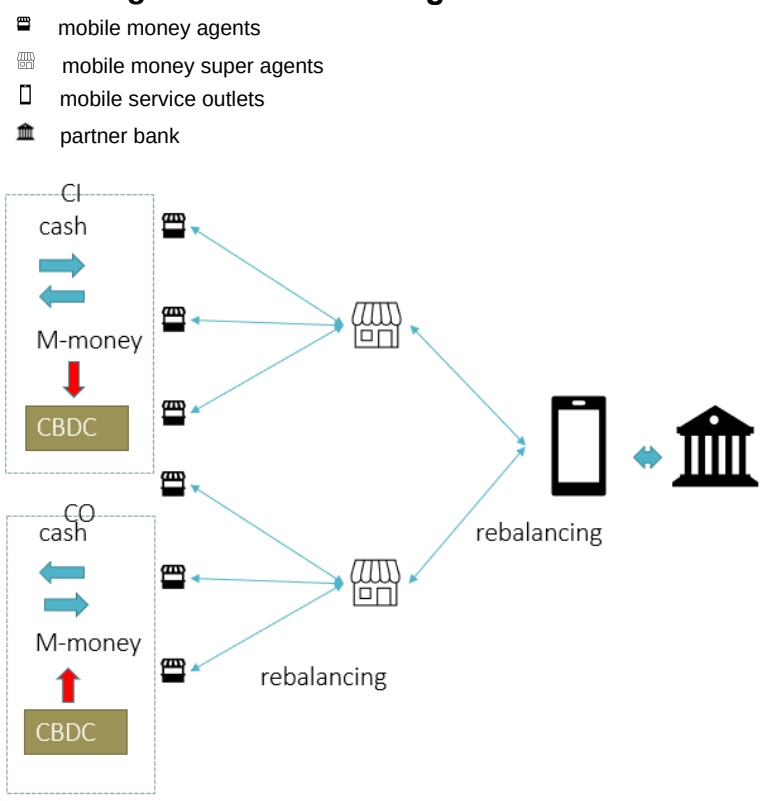
Source: Author's illustration based on a stylized network model (Annex II).

1/ $N' = \emptyset(N)$ is the function governing the evolution of N, the size of CBDC adopters. *N'* represents the size of consumer h who choses to adopt CBDC when the size of an existing network is N. $\bar{\bar{N}}$ and $\underline{N}$ represents the size of all consumers in the economy and the minimum size of the network for CBDC to attract any consumer. For model assumptions see Annex II.

Desirable Roles: Financial Inclusion and Remittance enabler?

In this section, we discuss whether and how the eNaira can rise to Nigerian authorities' expectations in fostering financial inclusion and boosting remittance. eNaira project is still a work on progress and remain in an early stage. Hence, it would be too early to make a judgement on whether adopting a retail CBDC in Nigeria under Africa's challenging economic and financial contexts was a good idea, and Nigeria was indeed prepared for it. However, the experience of the first year suggest that it is technically do-able at least for those SSA countries with relatively strong operational capacities. It also suggests that operationalizing CBDC's enabling potential may require a robust strategy—which goes beyond a narrow focus on CBDC itself. The selection of a good external technology provider with strong experience is also essential.

Figure 4. CBDC's Integration into an MPS



Source: Authors' elaboration.

Setting Right Relationship with Mobile Money

A retail CBDC has a potential to either compete with or complement private digital money—particularly mobile money—which means that county authorities need to decide which relationship with it to pursue as a part its CBDC strategy. One option is for the central bank to pursue a complementary relationship with mobile money—by staying out of retail interactions[32] and providing CBDC to existing market players, among others, as a bridge for interoperability.

As in other developing countries, mobile money providers (MMPs)[33]—also known as MMOs[34]—in Nigeria have provided bank-like solutions to deposit and money transfer services. These are done through their vast networks of cash-in cash-out (CICO) agents (Figure 4). The only equipment needed at the agent level is a mobile phone, which gives mobile money agents a universal presence. While remaining as an independent payment system, the eNaira can be effectively integrated into the existing mobile payment system (MPS) by allowing (1) MMPs to onboard[35] their clients to eNaira wallets and (2) allowing mobile money apps to integrate eNaira wallets using a software interface called APIs[36].

[32] An alternative model of complementary is a case where CBDC targets a fraction of population—for whom a private sector solution for financial inclusion would not reach (e.g., poor people in advanced countries who do not have a financial account and rely only on cash transaction—for whom a CBDC will mitigate their further economic exclusion due to cashless trends). Such a model, however, would not resonate well in SSA due to broad presence of mobile money access, and lack of comparative advantage of CBDC in terms of its access capacity relative to the mobile money. This comparative advantage may be established if CBDC were to be exclusively used as the last mile instrument for, say, social cash transfers. But such advantage will dissipate if mobile money were also allowed to be used for it.

[33] Unlike many other SSA countries with successful MPS models (e.g., Kenya and Ghana), Nigeria does not allow mobile network operators (known as Telcos) to become lead initiators of mobile money services. Its mobile money framework builds on either bank-led (bank and/or its consortium as Lead Initiator) or nonbank-led (corporate organization duly licensed by CBN as Lead Initiator) model. However, Telcos can participate in the mobile money business through its Payment Service Bank subsidiaries.

[34] Mobile Money Operator. MMOs and MMPs are used interchangeably in this paper.

[35] This seems to be already happening in the 2nd (and ongoing) phase of the eNaira project—as eNaira system coverage is extended to customers without bank accounts but with mobile phones—whose identity verification (and KYC checks for those with mobile money accounts) and onboarding to MPS is already conducted by MMPs.

[36] A mobile money app can communicate with the eNaira system through an Application Programming Interface (API), with allows the former to access the contact end point of the latter using pre-defined protocols for making requests. In the context of APIs, the word "interface can be thought of as a contract of service between two applications", which "defines how the two communicate with each other using requests and responses" (https://aws.amazon.com/what-is/api/#:~:text=API%20stands%20for%20Application%20Programming,other%20using%20requests%20and%20responses).

In a model of complementary relationship, the CBDC system will refrain from formally acquiring its own retail access network[37], and not attempt to provide retail bank or mobile money-like ancillary retail client services (e.g., transaction record inquiry, notifications and alerts, automatic transfer services). In this model, customers without bank account would normally deposit cash into CBDC wallets after first loading it into their mobile money wallets—although direct access to CBDC is possible[38]. Customers can then receive electronic funds (e.g. payroll) either to their mobile money accounts or CBDC accounts (or initiate electronic fund transfers or payment from either of them)—however, they will tend to use mobile money wallets as the main current transaction account because CBDC wallets lack the convenience of retail client services (e.g., payment tracking), which is a critical feature for the former. Ceilings on CBDC transactions and balances will also limit substitution from mobile money to CBDC.

Integration between the eNaira and mobile money wallets would enhance the store of value function of the mobile money. Money stored in mobile money accounts is subject to credit risk—which can be, at times, more severe than those of bank deposits—considering (1) operational or fiduciary risks involving MMPs[39]; and (2) credit risks of the partner bank at which mobile money depositors' funds are safekept in the form of a pool account[40]. Integrating the eNaira into mobile money will allow users to keep using their preferred point of contacts for their cash in-cash out needs while adding a risk-free option (i.e., eNaira) for safekeeping money.

[37] This limitation does not undermine the common understanding of CBDC, that is digital asset issued by the central bank, accessible by everyone and used in transactions for goods and services. It will be accessible to customers with mobile money accounts through transfers of value from (or to) these account to (or from) their CBDC accounts. And those without mobile money accounts (but with CBDC account) can convert their cash into CBDC by using (mobile money or bank) agent networks as an informal intermediary (e.g., an agent can take cash from the client and transfer his/her CBDC balance to the client acting like an informal CBDC cash-in agent; and conduct a transaction in the reserve direction like an informal CBDC cash-out agent). In that sense, the second model does not by itself preclude CBDC's substitution for mobile money. However, the informal nature (i.e., agents acting without formal contractual agreement with the central bank) of the relationship between the agents and CBN—combined with non-provision of ancillary retail client service by the CBN—diminishes incentives for clients to switch from mobile money to CBDC.

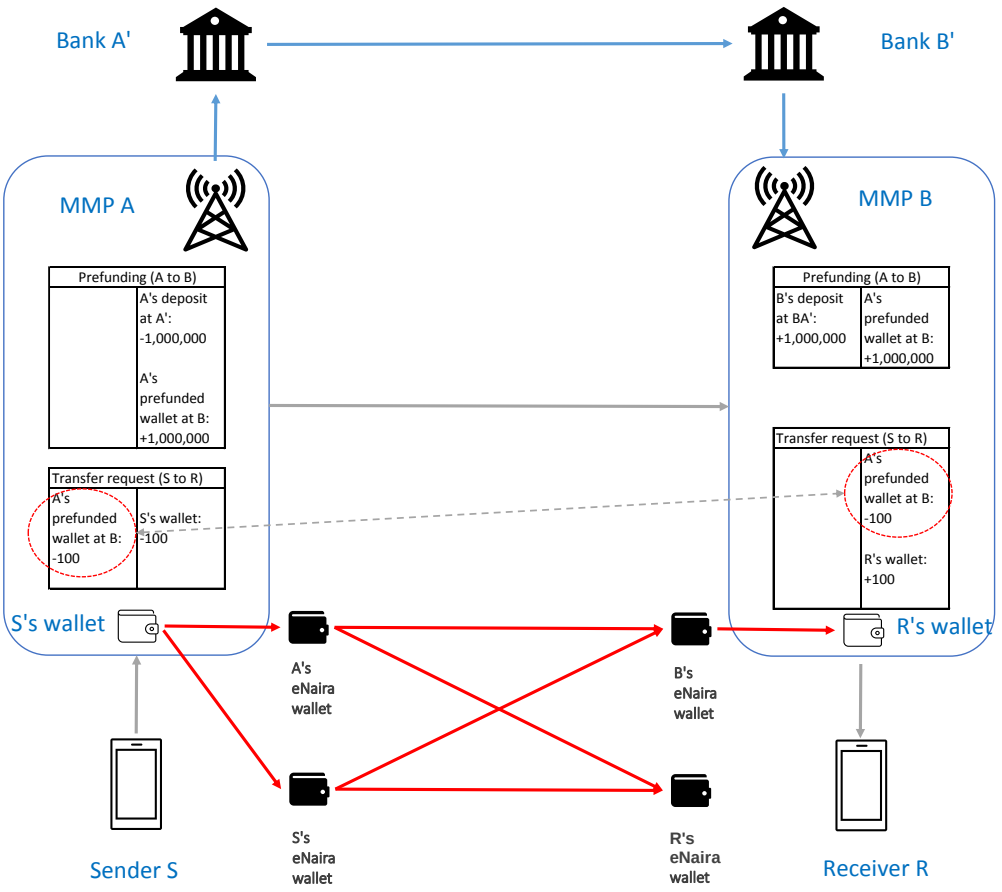
[38] While CBDC in this model would not provide bank or MMO-like ancillary retail services, it can still be seamlessly used in transactions for goods and services just like physical cash.

[39] These entail for example cybersecurity risks, risks of fraud, and risks of accounting system errors. These risks are partially mitigated by the requirement (by NDIC) for MMPs to take Fidelity Bond Insurance for any losses caused by fraudulent acts of their staff and agents.

[40] The pool account takes the form of a Bare Trust arrangement, wherein MMPs act as merely the custodian of the fund—whose ownership belongs to individual MMP subscribers/customers. The credit risk of the bank carrying the pool account is mitigated by NDIC's deposit insurance which protects mobile money account deposits up to N500,000 using a pass-through arrangement (i.e., deposit insurance is ultimately paid to the individual mobile money subscribers/customers and not the MMPs).

The latter can be achieved through transfers from a mobile money wallet to an eNaira wallet—likely at some costs[41]. Users will keep relying on MMPs for retail financial services.

Figure 5. Mobile Money Interoperability: Before and After CBDC [1/]



Source: Authors' elaboration.

1/ Solid grey arrows represent money and order flows under the current model of interoperability arrangement between two MMPs (a prefunded model), the dotted grey arrow book reconciliations, and blue arrows prefunding flows. Red arrows illustrate possible path of interoperability after CDBC introduction in four different scenarios: (1) both S and R have CDBC wallets; (2) only S has a CBDC wallet; (3) only R has a CBDC wallet; (4) either S nor R has a CBDC wallet.

[41] MMPs are likely to charge fees for transfers from mobile money account to customer's eNaira wallet. Customer fund transferred to eNaira wallets will be stored there until used for cash withdrawal or payment to a third party (either retail customers or a merchant). Cash withdrawal will require a transfer back to the mobile money account, which may also trigger fees. Transfer to a third party with an eNaira wallet will be cost free—unless CBN changes its fee policy.

eNaira may also enhance mobile money's means of payment function. Currently, mobile money's means of payment function is restricted by limited acceptability by merchants and high costs of transfers of between mobile money accounts—particularly if they are with different service providers. Nigeria's fragmented MMP landscape further aggravates the problem. As the central bank product, the eNaira has a better potential for universal merchant acceptance than any individual mobile money product. Thus, its integration with the existing mobile money apps will provide a powerful backup in the event that a mobile money product is not accepted by a merchant. The eNaira can also help significantly reduce the costs arising from interoperability and make a person-to-person transfer cheaper and easier between different MMPs. Consider an example of an MMP A's customer sending 100,000 naira to an MMP B's subscriber. Right now, MMP A needs to execute the transfer through a complicated interoperability arrangement with MMP B (Figure 5)[42]. However, once MMP A onboards its subscriber to the eNaira system, it can first let customer S's funds be transferred to his eNaira wallet. It can then push this through to customer R either directly (wallet-to-wallet) or indirectly (i.e., with MMP B acting as the recipient's wallet intermediary).

An alternative option for CBN would be to set a substitutive relationship with the mobile money. More specifically, it could let the eNaira replace the mobile money as the key instrument for financial inclusion. For this, the eNaira will first need to establish a direct retail presence, for example, by outsourcing existing agent networks for the CICO needs. In fact, CBN is already using banking agents as its last mile points of access since it opened the eNaira to people without bank accounts. Once a customer is onboarded to CBDC, would CBDC be able to readily substitute mobile money? It is difficult to imagine a world where all retail service functions conducted by the MMPs—e.g., transaction tracking and record inquiry or automatic bill payment—are carried out directly by central banks: considering, among others, legal/political constraints and lack of sensible business cases or resources. However, these functions can be replicated by a private-public partnership where central banks collaborate with private service providers, who gain access to their customers' CBDC wallets though APIs—based on the customers' pre-approval[43]. This approach however entails a risk of a central bank prompting an industry reshuffle—which could involve governance risks and distortions related to the governments' picking the winners.

Use of eNaira to Make Remittance Cheaper and Faster

Unlike central banks contemplating an integrated multi-currency platform operated by a group of them, CBN has launched the eNaira as a single currency national CBDC system. As such, the use of the eNaira for

[42] Figure 5 is an illustration of bilateral interoperability model, which is one of three most common interoperability models according to GSMA (2020). Nigeria's mobile money regulatory framework requires MMPs to connect themselves to central switch (NIBSS), to ensure interoperability. However, interoperability between different MMPs still require clearing and settlement process, which is costly, data intensive, and risky.

[43] In fact, collaboration with payment initiation service providers is already done with the eNaira integrated in open banking apps such as Flutterwave (Flutterwave adds Nigeria's eNaira as payment option for merchants | Reuters).

remittance will likely need to consider the following two options[44]:

- First, granting foreign IMTOs direct or indirect access to the eNaira is an important consideration. *In case of direct access*, foreign IMTOs will be able to own eNaira merchant wallets[45] and use them to intermediate remittances by, say, selling the eNaira to the remittance senders (in exchange of foreign currency)—who can then make a wallet-to-wallet transfer to domestic recipients. Alternatively, IMTOs may also provide wallet service to the senders by transferring agreed amounts of the eNaira to the designated domestic recipients[46] in exchange for foreign exchange paid to them by senders. *In case of indirect access*, IMTOs will need to rely on eNaira wallet services provided by their Nigerian domestic partners[47]. While CBN is still contemplating on options, the first modality (i.e., granting direct access) appears to be its preferred one[48].

- Second one is by using domestic remittance service providers who already have access to the eNaira. These entities may simply reach out to remittance senders online, receive foreign currency payment from them (e.g., through payment service apps such as paypal) and then transfer the corresponding amount of the eNaira to the recipient. However, such a scenario presumes building a new remittance franchise online—which may be challenging—given the dominance of existing IMTOs and their ability to provide services both on and offline.

[44] See Report to G20: Central bank digital currencies for cross-border payments, BIS, CPMI, IMF, WB, July 2022 for modalities being explored for the use of CBDC for remittance. According to the report, a scenario envisaging cooperation and coordination among central banks "could happen either by allowing foreigners to access the domestic CBDC solution or by means of multi-CBDC (mCBDC arrangements).

[45] This will get more complicated if IMTOs were granted the power to act as financial institutions in the eNaira network—which are authorized to conduct client onboarding and required to do KYC checks. In such a scenario, a proper arrangement will be needed between home-host supervisors to ensure foreign IMTOs follow proper AML/CFT procedures in the process of onboarding.

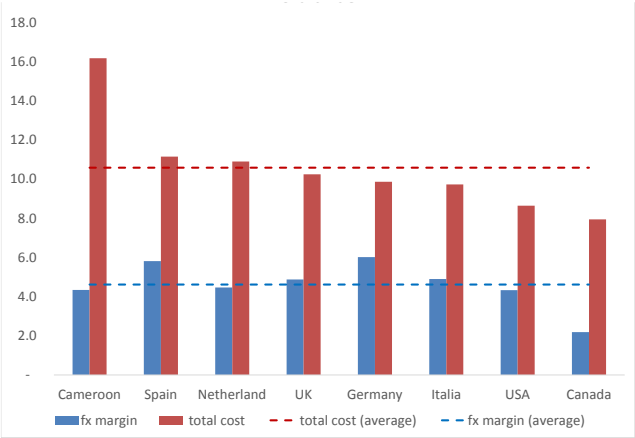
[46] The IMTO's domestic partner may also provide wallet intermediation service for the recipient (e.g., by receiving eNaira into their wallets and make congruent payment to the recipient either electronically or in person).

[47] In this model, foreign IMTOs may send instructions to its domestic partner to conduct wallet-to-wallet naira transfer (from say its prefunded naira account) to the recipient after receiving foreign currency payment from the sender. The foreign IMTO's transaction with the domestic partner' can be settled through the latter's correspondent bank.

[48] This is based on CBN's responses to our written queries (see Appendix 2) and follow up onsite meetings in the context of IMF's 2020 and 2021 Article IV consultations with Nigeria.

Use of the eNaira for remittance may make remittances cheaper by help streamlining the remittance process. As illustrated by Box 3, cross-border remittance process flow comprise (1) multiple wire transfers within two different domestic payment systems (e.g., U.S. and Nigeria payment and settlement systems) typically linked up through domestic correspondent banking relations; and (2) foreign exchange transaction involving correspondent bank in the remittance sending jurisdiction and its counterparty—whereby the former credits the latter's correspondent (or nostro) account (in the currency of remittance originating country) and the latter crediting the recipient's bank (in the currency of the remittance receiving country) either directly or through intermediary banks. The credited amount is used to provide cash or deposit balance to the remittance recipient (either directly or through an IMTO).

Figure 6. Nigeria: Cost of Remittance by Source Countries (in percent, 2020Q2)



Source: World Bank, Remittance Prices Worldwide.

To which extent can this flow be simplified once the eNaira is used as a component in the remittance process? The effect may not be ignorable. But it will also not be big enough to change the fundamental fact that remittances are expensive. As explain in Box 4, the eNaira will neither simplify the existing chain of domestic transfers within the remittance sender's border nor eliminates the need for a foreign exchange—for the money to cross the border. However, once the money reaches the correspondent account say within US of a Nigerian bank, the bank can simply send the eNaira, by wallet-to-wallet transfer, to either the remittance sender or receiver. There is no good reason to expect that the Nigerian bank that conducts foreign exchange function in this value chain will apply a narrower exchange spread, simply because it is using the eNaira, than the one applied in the existing framework. However, once the money crosses the border, there is no need for intermediated transfers within Nigeria—as long as the recipient has an eNaira wallet. This streamlining will help

saving the overall transaction cost. Given that exchange spread tends to account for about a half of overall remittance cost for Nigeria, the savings could reach a quarter of the total cost[49] [50].

[49] According to World Bank's Remittance Prices Worldwide database (http://remittanceprices.worldbank.org), the average cost of sending 200 dollars worth of cash (excluding other means of payment such as bank deposits) from various surveyed countries to Nigeria was 10.4 percent in 2020Q2, of which 47 percent (4.8 percentage points) was attributed to exchange rate spread. Assuming that the rest of the cost is evenly divided between within-border fund transfer costs in the remittance sending and receiving jurisdictions, about a quarter of the total cost (10.4 percent) could be saved by streamlining the domestic fund transfer process within Nigeria.

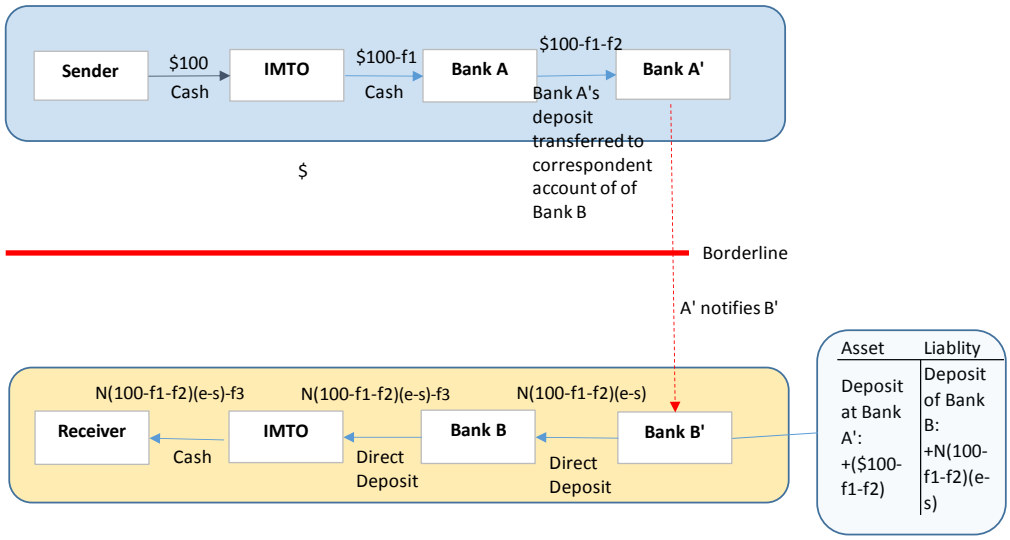
[50] The cost saving expected to arise from cross-border use of CBDC is a widely accepted proposition in the CBDC literature. For example IMF(2020) argues that due to CBDC's ability to be "transferred over a peer-to-peer system operating around the clock their use flattens the multi-layered correspondent banking structure, shortens the payment chains, reduces transaction time, and facilitates increased competition among service providers".

Box 3. Remittance Process (Current): A Stylized Example

The box presents an example of a Nigerian residing in U.S. remitting $100 from U.S. to a receiver at home using an IMTO (e.g., Western Union) as the intermediary. As illustrated below, remittance process involves (1) chains of domestic fund transfer payment within both US (from Sender to Bank A') and Nigerian borders (from Bank B' to Receiver), (2) currency conversion (done by Nigerian respondent bank B' in this example); and (3) a correspondent banking relationship between a US and a Nigerian bank (i.e., Bank B' opening a USD correspondent account in Bank A' and Bank A' opening a naira correspondent account in Bank B').

The transaction is expensive because all intermediaries take a dip on the money that comes in their way, slow because foreign exchange transactions typically take days to settle, and obscure as senders of small remittances (who are unsophisticated compared with financial investors or companies doing trade) typically are unaware that intermediaries deduct their fees/spreads from the amount received by the beneficiary ($((f_1+f_2)s+f_3$ in this example)—which generally is unnotified to the sender.

Figure 7. Graphic Illustration of the Current Remittance Process 1/



Source: Author's elaboration

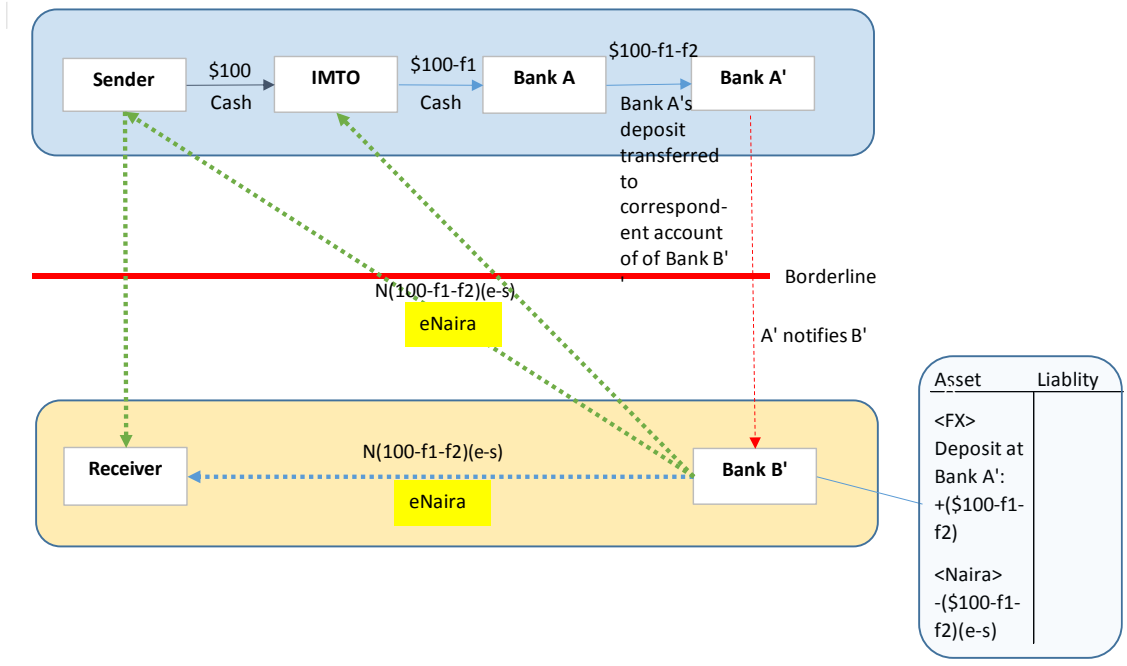
1/ fi (i=1, 2, 3) denote fees charged by various intermediaries. e and s denote exchange rate applied for buying USD and its spread with USD selling rate. Fair value of the USD deposit holding X of Bank B' would be Xe, and thus Xs=Xe-X(e-s) is the de facto fee charged on FX transaction with banks' customers.

Box 4. Remittance Process (with eNaira): Possible Scenarios

In this box, we illustrate how use of CBDC may change the remittance process. Note that the Figure 8 is the same as Figure 7 up to the point that the remittance flow reaches the Nigerian banking system—when the U.S. correspondent bank (Bank A') credits its Nigerian counterparty (Bank B') with $\$100\text{-}f_1\text{-}f_2$. From then on, the Nigerian system does not need to rely on the traditional payment system—as far as the sender's IMTO has an agency arrangement with Bank B', so that the latter may act on the former's behalf. If there is such an arrangement, Bank B' can simply transfer its eNaira balance to the receiver. Assuming zero cost involved in eNaira transfers (and also full pricing transparency), the receiver will receive $N(100\text{-}f_1\text{-}f_2)(e\text{-}s)$—thus overall cost of remittance for the users will be reduced by f_3. Alternatively, Bank B' may send the same amount back to sender—who can then send the money directly to the receiver.

One other option would be a pre-funded IMTO model, where the IMTO in the US side is allowed to hold the eNaira. In this model, the IMTO will keep pre-funded eNaira balance to respond to daily eNaira cash demand. Since an IMTO has both market power and information advantage over individual remitters, it may be able to strike a better deal on fees and exchange rate spread to purchase the eNaira from Bank B' through the same correspondent banking channel. Then it can sell the eNaira directly to the remittance sender or transfer its eNaira balance to the receiver upon the senders' request. In certain cases, as shown in Brazil's Pix solution, Bank B' can even be completely bypassed and services can be rendered directly by the central bank. The extent to which the cost savings, if any, from better deals on fees and exchange rate spreads, is passed on to the remittance customers will depend on competition and price regulation (if feasible). An eNaira funding market may also emerge in this scenario to meet the IMTOs' eNaira liquidity management need.

Figure 8. Graphic Illustration of a Possible Remittance Process using CBDC 1/



Source: Author's elaboration

1/ fi (i=1, 2, 3) denote fees charged by various intermediaries. e and s denote exchange rate applied for buying USD and its spread with USD selling rate.

Realizing eNaira's Enabling Potential: Policy Considerations

Broadening the eNaira's public adoption and realizing its enabling potential will require careful consideration of policy adjustments. For an example, certain aspects of current exchange rate policy, if left unaddressed, would keep blocking the eNaira's usage for remittances. For another, use of the eNaira for social cash transfer program will help unlocking its potential for financial inclusion.

Addressing the parallel market problem.

Since the onset of COVID-19 crisis in 2020, Nigeria's parallel market spread has remained at double digits. It has since then increased to 60 percent (as of end-2022). In such environment, it is very difficult to keep remittances flowing through the official channel as there are multiple alternative channels which are far more attractive. The simplest one is physically carrying foreign currency into Nigerian borders and selling it to domestic Bureau de Charge (BDC) at parallel market rates. A Nigerian diaspora in, say, New York can also make an arrangement with a trusted counterparty, for example, in Lagos whereby he makes a dollar payment on the latter's behalf in the US (e.g., to pay school fees for the counterparty's beneficiary), while the latter sends a naira payment to the former's beneficiary in Nigeria. These informal transactions are typically done at a negotiated exchange rate—which is usually guided by the parallel market rates in Lagos.

Against this backdrop, since December 2020, CBN has required all remittance to be made in the form of the currency of origin—so that beneficiaries of the remittances may receive the proceed either in the form of FX cash or domiciliary deposit balances. The new policy essentially removes the need for currency conversion in the official remittance process.

Usage of the eNaira in the remittance process would therefore imply reintroducing the element of currency conversion in the remittance process. If the parallel market spread problem is left unaddressed, the newly furnished channel of official remittance is likely to face the same the fate as in the past of being shunned—unless the currency conversion is done close to the parallel market rate—because users' opportunity cost in the form of the forgone parallel market spread—which they would incur by sticking to the official channel—would dwarf any savings in the user cost due to efficiency gains brought by the eNaira. IMF's policy advice has been a multi-step approach to exchange rate unification, starting with greater flexibility in the I&E rate[51].

Use of eNaira for Social Cash Programs

As discussed in the previous section, the eNaira's integration into mobile money can boost user tractions for both the eNaira and mobile money. Given Nigeria's high incidences of poverty, pressing needs for social programs for poverty reduction, and the importance of financial inclusion in economic empowerment, Nigeria has seen social cash programs as a key fiscal use case for the eNaira from the very beginning.

[51] For details see Nigeria 2021 and 2022 Article IV Consultation Staff Reports.

Bundling the eNaira with mobile money may be a sensible option once the framework for integrating the two systems is set. For example, the last mile fiscal agent (who may also be a trusted mobile money agent in that area) who delivers social cash to villagers may be empowered to on-board on site the beneficiary to both mobile money (from one of the service providers he represents) and the eNaira after quick KYC checks. In case that the beneficiary already has a mobile money account, the agent may simply add eNaira access to the client's mobile money app. In this manner, social cash recipients can keep social cash as the eNaira which is risk free, and use it for electronic payment or transfers later both directly or after first converting it to mobile money. In addition, they can always turn it into physical cash anywhere through mobile money CICO networks.

This will significantly enhance the efficacy of a social cash transfer program**.** Once the beneficiaries are brought into the eNaira system, the cash distribution part of the program becomes essentially cost free, as the CBN can directly and electronically transfer money from the government's to the recipients' wallets. The recipients can then also receive and keep their money electronically—free from the risk of embezzlement or security incidents. It also automatically expands financial inclusion to the social cash recipients who will now have access to the integrated system of mobile money and CBDC.

Boost Merchant Adoption of eNaira

Boosting eNaira participation on the merchant side of retail transactions is a significant challenge to overcome in order to encourage adoption and integrating network effects across Nigeria. While integral benefits do exist within CBDC network use for merchants, such as less expensive transaction fees when compared to legacy payment networks, decrease in the cost of carrying cash for a business, and security, it is still a challenge to increase merchant adoption without integrated benefits and amid lagging consumer adoption. Integrating benefits directly for merchants is therefore an important step in inciting increased adoption.

Integrated benefits within payments, incentivizing both merchants and customers, would be a powerful tool within eNaira and other CBDC-based systems to increase take up and network effects on both sides of the payment equation. Take a possible CBDC-based payments system within utilities as a possible scenario: a CBDC-based payment, via programmable payments functionalities, could create incentives in which customers and suppliers could receive instant rebates or cash transfers to either incentivize more production of electricity (on the supplier side) or incentivize more efficient use of electricity at peak times (on the customer side) to balance a possible grid.

These programmable payment functions would also instantly give the supplier, government, and delivery company their share of a payment instantly, at a much faster rate than comparable legacy payment systems which take days (and even weeks at times) to settle and increase the speed of investment and adoption of CBDC-based systems. These integrations would allow systems to accelerate investment from the private sector since payments via CBDC-based systems would be much less risky and contractors/utilities are able to access their cashflows at a much faster rate.

Stay vigilant on monetary and financial stability impacts.

Hypothetically CBDC may crowd out banks' core function of financial intermediation acting as a bank deposit alternative—which is safer, cheaper and faster to move around. Using a simple bank balance-sheet based

model, BIS (2021) illustrates that even in a benign scenario, where deposit and reserve losses post CBDC introduction is offset by wholesale funding to back full restoration of LCR to the pre-CBDC levels (which is a necessary condition for banks to maintain pre-CBDC credit levels), banks will face lower profitability—which has a financial stability implication. Moreover, CBDC may increase the risk of a bank run, by acting as a safe haven asset, in times of panic and distress[52]. Thankfully, the programmable nature of the DCMS platform can enable dynamic transaction and holding limits for each wallet type in the system; lower holding limits could be set in times of financial stress and raised when deemed appropriate by the CBN. Similarly, the auto-sweep function for merchants mentioned earlier (the end of day conversion from the eNaira to deposits at the merchant's linked bank account) helps to mitigate the bank funding risk. Overall, the increase in economic data will enable CBN to monitor financial conditions more closely, and to make better informed and timely monetary policy decisions.

Concerns about bank funding do not seem to be immediately relevant for Nigeria given the low levels of user adoption. However, Nigeria still will need to keep vigilance against risks coming from possible breakthrough in its public adoption and resulting deposit-to-CBDC shift. CBN's decision not to remunerate the eNaira and to adopt tiered ceiling on transaction and balance may be deemed as adequate safeguards in that regard. Going forward, CBN should keep modernizing its monetary policy operational framework[53] to effectively deal with possible liquidity and funding shocks[54] caused by the acceleration of eNaira adoption.

While the eNaira's niche use in cross-border payment (largely remittance) is unlikely to affect capital flows significantly, a wider CBDC adoption in other countries—or domestic adoption of global stable coins—could cause currency substitution and increase capital flow volatility[55].

[52] BIS (2021) argues that stablecoins also present a similar risk.

[53] See 2020 Nigeria Article IV Staff report and Ree (2020) and for details.

[54] As in BIS (2021), a shift to CBDC may cause simultaneous loss in banking deposits and reserves, thus causing strains on liquidity conditions. If banks as a whole attempt to make up for the reserve shortage by wholesale funding (e.g., issuance of debt of maturity of 2 or more years to avoid increase in LCR denominator), this may result in strains on funding conditions.

[55] According to IMF (2021), "These new forms of digital money can be supplied directly by nonresident service providers to a country's residents through the internet…bypassing traditional payment systems, through which exchange restrictions and CFMs are typically enforced." The ensuing regulatory challenges will require effective surveillance on market and technological developments and continual updating of regulatory framework and tools to remain effective in a rapidly changing regulatory environment.

Watch out AML/CFT risks

CBDC's impact on AML/CFT risks may not be straightforward and not yet fully understood. To the extent that the eNaira facilitates a move to a cashless economy, it may alleviate AML/CFT risks[56]. However, its element of anonymity and digital form may also bring new and untested form of risks as have crypto currencies in recent years (e.g., bitcoins requested as a ransom money in recent ransomware attacks). eNaira's design features seem to be largely appropriate to address AML/CFT risks, including its adoption of account based DLT—where all transactions are traceable under the constraints of relevant privacy and data protection laws and regulations[57]—and tiered KYC framework along with tiered transaction ceilings. However, guarding against AML/CFT risks hinges on the strength of Nigeria's existing AML/CFT framework—which still faces weaknesses despite the authorities' laudable actions[58] to address deficiencies identified by 2021 GIABA Mutual Evaluation Report. Sustained efforts will be needed to address the remaining deficiencies and to adapt the framework to new risks brought by the eNaira.

[56] In a bid to prevent funding of illicit activities, the CBN rolled out newly-designed high denomination naira notes on December 15, 2022, for parallel use with old notes until January 31—after which the latter was set to lose legal tender status. The CBN expected the note renewal initiative would brining cash outside banks back into them—thus cause cash-to-deposit shifts and help expediting transition to a cashless economy. However, the initiative has faced implementation challenges due, among others, to its compressed time frame, printing capacity constraints, and cash shortages. On March 13, CBN extended the deadline of cash swap to end of 2023 in compliance with the Supreme Court's March 3 judgement.

[57] In fact, a CBDC is likely to feature levels of traceability which is comparable to bank deposits in an account-based system where account holder identities are completed recorded and verified—e.g., by allowing a tracing of illicit activities by law enforcement agencies following lawful processes (e.g., based on subpoenas). On this basis, some policy makers recently saw alleviation of AML/CFT risks as an advantage of a retail CBDC (e.g., see Policy Objectives for a U.S. CBDC System, The While House). In a similar vein, some analysts are raising concerns that CBDC will reinforce tendency towards technologically savvy surveillance states (https://www.lawfareblog.com/international-security-implications-central-bank-digital-currencies).

[58] For details see Nigeria 2022 Article IV Consultation Staff Report.

Concluding Remarks

In this paper, we took stock of the first year of Nigeria's eNaira launch. In terms of the technicalities, the eNaira project has had a relatively smooth start, having proven its 24/7 operational resilience. No major accidents occurred, despite the CBN's ambitious early foray into this unchartered territory of central banking, which was feared to be beset with unknown pitfalls. In terms of the market's acceptance, however, the project has not yet moved beyond the initial wave of early adopters with the retail clients onboarded falling short of one percent of active bank accounts. The Nigerian authorities have already begun their move to the second phase where the eNaira coverage is expanded to clients with no bank accounts and no internet. Its expansion to remittances also remains an envisaged future course of action. While such an expansion may be steps in the right direction, the eNaira's project strategy going forward will need to answer a few critical questions.

First, the expansion of a retail CBDC like the eNaira to financially-excluded people, particularly in SSA economies, may likely results in competition with mobile money, a relatively more established bank deposit-alternative in these economies, given that the retail use case of the two products appear to be similar (i.e., safekeeping, P2P transfers, and means of retail payment). In an economy where oligopolistic market power is a predominant concern, the use of a retail CBDC to enhance competition may be attractive for policy makers. However, the same objective may also be achieved by competition policies[59] and without risking central banks' straying into an area of commerce, or being deemed to crowd out the private sector, based on their money printing powers. In an economy like Nigeria, which is falling behind in terms of mobile money penetration, CBDC has a catalytic potential to offer. This would be by functioning as a bridge for cheaper and faster interoperability among different mobile money operators and also as a safer store of value. CBDC's synergy with mobile money along this line can also provide an important means for further digitization of government finance, for example, in social cash transfers—which can be made faster, more tractable, and cost effective.

Second, SSA economies intending to introduce CBDC will need to carefully design modalities of its use for cross-country payment, particularly remittances—given their importance as the source of foreign exchange for many and their depressingly high cost. Our analysis on Nigeria suggests that cost savings from integrating CBDC as a bridge vehicle in the existing remittance process may be nontrivial, albeit not huge. A more game changing cost saving is likely to occur in the context of a multi-currency CBDC planform, which is being experimented by a few central banks. Because that would allow direct CBDC-to-CBDC interoperability—without the need for foreign exchange arrangement through correspondent banks. Therefore, it would be very important for SSA banks to design their technological models of CBDC in such a way that it may be interoperable with other CBDC systems[60]. In this sense, close cooperation and information sharing among central banks in their collective efforts to make the most of this new technological innovation will be highly valuable.

[59] See Ravi Manon (2022).

[60] The DCMS enables such functionality, which will likely be tested in the next year with other central banks utilizing the same platform, or those using complimentary structures such as mCBDC.

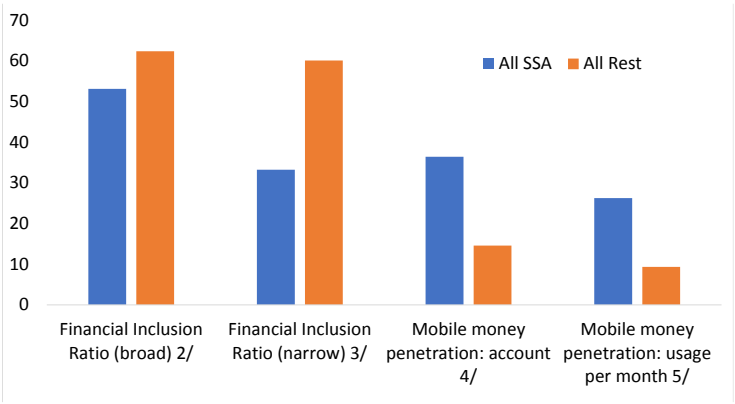
Broadening the eNaira's public adoption and realizing its enabling potential will require careful consideration of policy adjustments. For example, certain aspects of current exchange rate policy, if unaddressed, would keep blocking the eNaira's usage for remittances. Use of the eNaira for social cash transfer program will definitely help unlock its potential for financial inclusion enabler. A possible future breakthrough in the eNaira adoption may lead to liquidity and funding shocks and new forms of AML/CFT risks—which requires continued vigilance.

Annex I. Sub-Saharan Africa: Financial Inclusion and Remittance Challenges and CBDC

This box provides a quick snapshot of SSA's financial inclusion and remittance challenges, which are deemed as the region's most pressing impediments in poverty reduction.

Financial inclusion. Despite recent advances, SSA countries generally suffer from high levels of financial exclusion. Africa's leapfrog success stories in mobile money expansion shows a promise, but some countries have been less successful (e.g., Nigeria), while others now worry about negative consequences of their own success stories on the mobile money front, such as excessive market concentration (e.g., Ghana). Under this context, CBDC's potential to either compete with (thus countering oligopolistic market powers) or complement mobile money (thus helping to foster the industry) provides a potential for reshaping SSA's financial inclusion strategies.

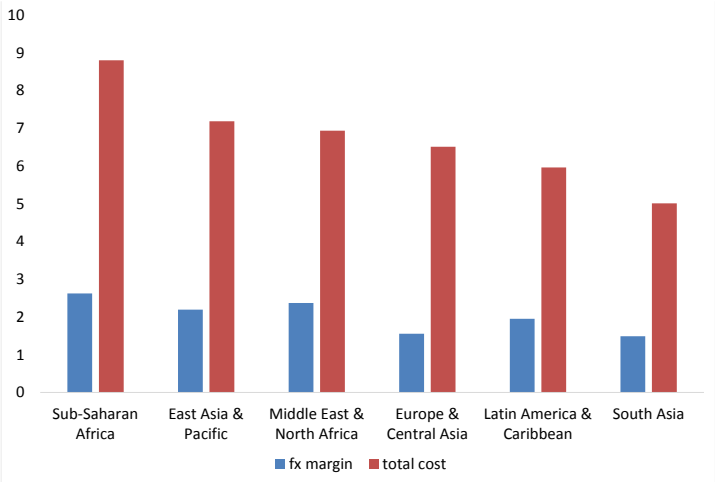
Figure 9. Sub-Saharan Africa: Financial Inclusion and Mobile Money Penetration 1/



Source: The Global Findex Databased 2021--World Bank (https://www.worldbank.org/en/publication/globalfindex)
1/ Excluding high income countries.
2/ Share of account holders among adults (i.e., people with ages 15 and above).
3/ Share of financial institution account holders among adults.
4/ Share of mobile money account holders among adults.
5/ Share of active mobile money account users (use twice or more a month) among adults.

Remittance. SSA countries also generally face higher costs of cross-border remittances, more so lately amid the trend of de-risking of international money transfer operators (IMTOs) by correspondent banks due to anti-money laundering and counter terrorist financing (AML/CFT) compliance costs. CBDC's digital and block chain nature, which could enable cross-CBDC inter-operability[61]—without relying on correspondent banking intermediaries—has been deemed to have a game-changing potential in cross border payment. Even without cross-CBDC inter-operability, CBDC may help trimming layers of intermediation in the current remittance process and thus bring cost savings.

Figure 10. Cost of Remittance by Destination Regions (in percent, 2020Q2 [1/])



Source: World Bank, Remittance Prices Worldwide.
1/ Nigeria's remittance cost went down significantly since Q2 2020, with CBN requiring remittances to be made in the currency of origin, which makes it inadequate for peer comparison.

[61] Note however that CBDC could provide such interoperability even without relying on the blockchain technology.

Annex II. A Network Model of CBDC

In this annex, we construct a highly stylized model to demonstrate how network effects may be applied to eNaira. Products such as a credit card or a phone would not be useful until there is certain critical mass of other people who also participate in the same product network. The same applies also to CBDC because if no one else uses CBDC, it has no use for it as a P2P transfer device or a payment instrument (i.e., one cannot use CBDC to transfer money or pay for goods or services if no one else has adopted CBDC wallets in the receiving end). In other words, the fate of CBDC will hinge on how its network effect[62] plays out.

As well established in the literature[63], network effect or network externality tends to result in multiple equilibria. A new network (e.g., an internet dating site) comes out, but it never makes a breakthrough from initial low adoption equilibrium, often dubbed "Death Valley" of startups—where a limited network reach makes it difficult to entice new clients, and the dullness in new client onboarding further shrinks the network over time. However, a few good and lucky network products manage to escape the Death Valley. They then expand and some manage to cross a tipping point. Beyond this, the network expansion become a snowballing dynamic—as the network growth itself increases the user value, enticing continued waves of newcomers, which prompts new waves of network growth.

Model

We illustrate these points using a simple stylized model of a network product—called CBDC. Let's assume an economy with a continuum of consumers $h \in [0, \overline{\overline{N}}]$. Consumer h's utility derived from a CBDC is represented by a utility function $u = f(N)$, where N represents the size of the participants in the network. Consumer h's reservation utility $\tilde{u}_h$is uniformly distributed in a segment of the real line $[\underline{u}, \overline{u}] \in [0, \infty)$. Consumer's choice problem is assumed to be binominal—i.e., whether to adopt a CBDC or not. A rational consumer h will choose to adopt CBDC if and only if $u \geq \tilde{u}_h$

Network Size Function

With this set up, we can derive a function $N' = \emptyset(N)$ where *N'* represents the size of consumer h who choses to adopt the CBDC when the size of an existing network is N. Then a fixed point N^*which satisfy the fixed-point condition $N^* = \emptyset(N^*)$ is the equilibrium size of CBDC adopters.

Figure 11 illustrates the process of deriving $N' = \emptyset(N)$ geometrically, which can also be done algebraically.

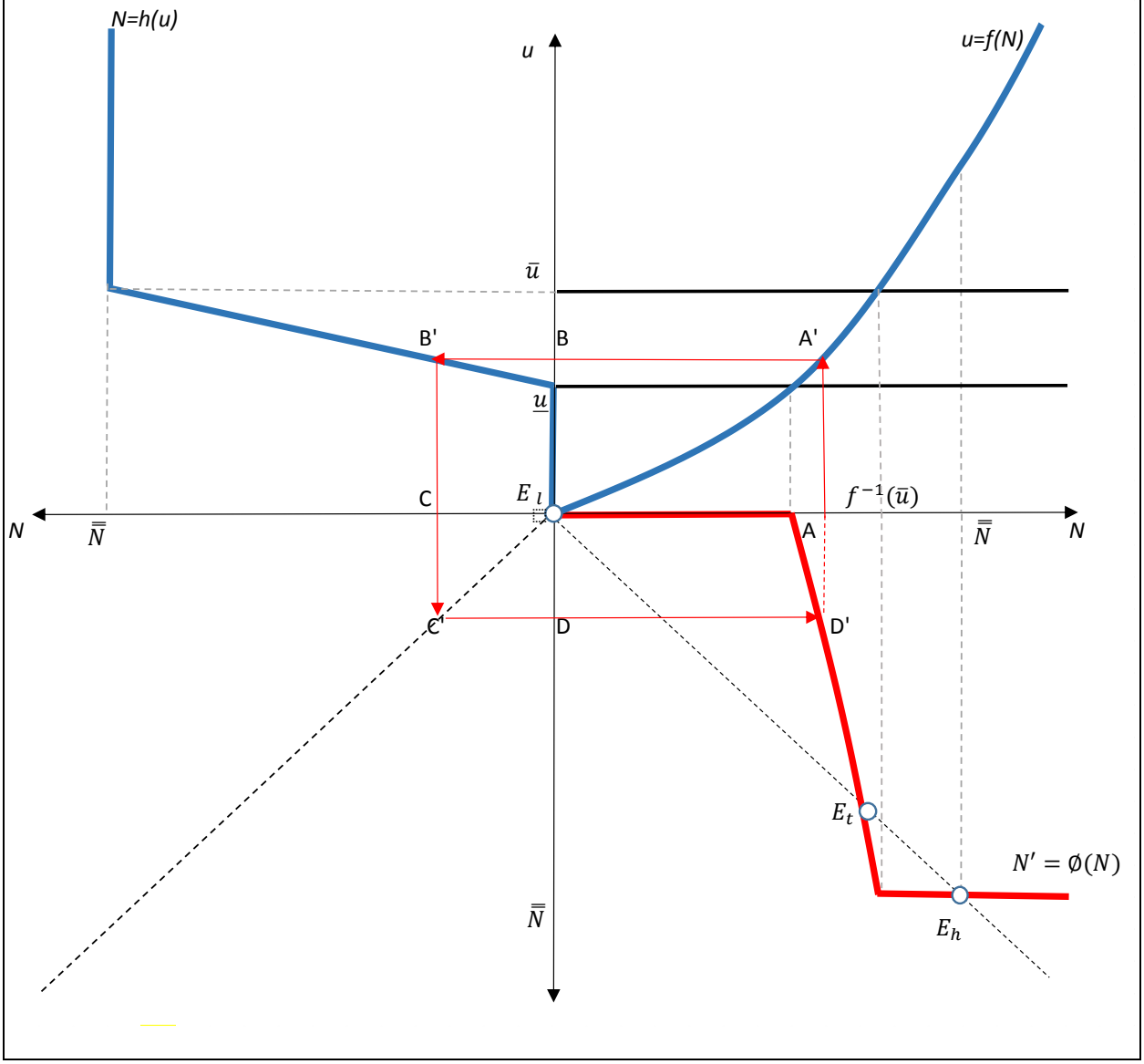
The first quadrant of chart plots the utility function $f(N)$. We assume that f is an increasing function of N and $f(0) < \underline{u}$. The first assumption ensures that network externality remains positive irrespective of network

[62] In their seminal 1985 American Economic Review, Michael Katz and Carl Shapiro defines the concept of network externality or network effect as follows: "There are many products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good." They add, "[T]he utility that a given user derives from a good depends upon the number of other users who are in the same network."

[63] For a concise but comprehensive survey of this strand of literature see Liebowitz and Margolis (1994).

participation. While this rules out the case of network congestion, the model can be easily extended to embrace the concept of congestion (i.e., function f peaking off at some point) —because our method of geometric derivation of the fixed point function $N' = \emptyset(N)$ will remain the same regardless of the shape of the function $f(N)$. The second assumption states the following: if nobody participates in the network, it is not attractive enough for even the consumer with the lowest bar (i.e., lowest reservation utility). This assumption is critical to attain both low and high adoption equilibrium—as if this condition is not met, the tipping point is so low that CBDC will always succeed.

Figure 11. Solving the CBDC Model



Now intersect the graph of $u = f(N)$ with a horizontal line $u = \bar{u}$ to derive $\overline{N} = f^{-1}(\overline{u})$, where f^{-1} is the reverse function of $u = f(N)$. Let's call $\overline{N}$ *Saturation Point* as once the size of network (*N*) reaches $\overline{N}$, then all consumers will participate in the network, and so $N' = \overline{\overline{N}}$. Stated differently at this point, $u \geq \tilde{u}_h$ for all h because the network effect has driven the utility to a high enough level to satisfy even the consumer with the highest reservation utility. Like wise, let's name $\underline{N} = f^{-1}(\underline{u})$ as *Entry Point* because $N' = 0$ below this point.

The second (upper left) quadrant shows the graph of function $N = h(u)$, which represents the size of network (or the measure of the adopters) when utility provided by the network (assumed to be homogeneous to all consumers) is u. Clearly, $h(u)$=0 if $u \leq \underline{u}$ and $\overline{\overline{N}}$ if $u \leq \bar{u}$. In between these two points, $h(u)$ take the form of a straight line connecting two dots: ($\underline{u}$, 0) and $(\overline{u}, \overline{\overline{N}})$. This is because $\tilde{u}_h$is uniformly distributed with a constant density. The algebraic representation of this line is as follows:

$$N' = \left(\overline{\overline{N}} - \left(\frac{\overline{\overline{N}}}{\overline{u} - \underline{u}}\right)\bar{u}\right) + \left(\frac{\overline{\overline{N}}}{\overline{u} - \underline{u}}\right)u$$

Once the function h is derived, derivation of the network size function ∅ is just a matter of double mapping—first from *N* to *u*, and then from *u* to *N'*–using the previously driven two functions f and h:

$$N' = \emptyset(N) = h\big(f(N)\big).$$

We can geometrically plot the graph of $\emptyset(N)$ in the fourth quadrant (lower right) as follows:

- *First quadrant.* Pick any point A in the first quadrant whose coordinates are (N_A, 0). Draw a vertical line AA' that reaches the graph of $u = f(N)$ by connecting A with A' (N_A, f(N_A)). Then draw a perpendicular line A'B that reaches point B in the vertical axis with coordinates (0, f(N_A)).

- *Second quadrant.* Extend line A'B by adding a horizontal BB' to point B' (f(N_A), h(f(N_A))). Then draw a perpendicular line B'C by reaching out point C (0, h(f(N_A))) in the second quadrant which is a R^2space consisting of (*u, N*).

- *Third quadrant.* Draw a 45 degrees ray using the graph of an identity function N=N. Draw a perpendicular line CC' by connecting C and C' (h(f(N_A)), h(f(N_A))). Draw a horizontal line C'D by connecting this to D (0, h(f(N_A))).

- Forth quadrant. Draw a horizontal line DD' by connecting to D'(N_A, h(f(N_A))). D' is a point subset of the graph of network size function *N'*=$\emptyset(N)$. By repeating this cobweb mapping technique, one can derive the complete graph of *N'*=$\emptyset(N)$ in the fourth quadrant.

Fixed points

Now that the graph of the function of $\emptyset(N)$ has been driven, one can derive the equilibrium size of the network N* by solving *N*=$\emptyset(N)$. The geometric equivalent of this is to simply to identify intersections between *N'*=$\emptyset(N)$ function and identity function N=N in the fourth quadrant—which satisfy the following fixed-point condition: if N=N* then N'=N*. Figure 11 shows that there will be three fixed points in our model if one additional condition is

met: i.e., if the saturation point $\overline{N} < \bar{\bar{N}}$. The condition states that the customer least likely to participate in the network would join the network if sufficiently high share of all customers is in the network. The model assumes that $f(0) < \underline{u}$, which implies $f^{-1}(\underline{u}) > 0$.Given these two conditions, we can show that *N'*=∅(N) function intersects with the graph of the identity function (i.e., 45 degrees ray) in three multiple points: E_l, E_t, and E_h— which we name as (1) low adoption equilibrium, (2) tipping point, and (3) high adoption equilibrium. We can also show that implies $f'(E_t) < -1$ or the graph of *N'*=∅(N) cuts through 45 degrees ray from the above, making it an unstable equilibrium. Likewise, we can show that $f'(E_h) > -1$ and $f'(E_l) > -1$, which render both E_l and E_h stable equilibria. Let's use a notation N_t^* for N* corresponding to the tipping point E_t.

Low and high equilibria

Our illustrative model shows that an initial push to gain market adoption for the CBDC is likely to face backsliding if a breaking-through is not made on the tipping point. On the contrary, once the tipping point is reached, then a self-reinforcing expansionary dynamic will kick in to bring the market to a full or near full adoption.

Figure 12. Tipping Point, High and Low Equilibria

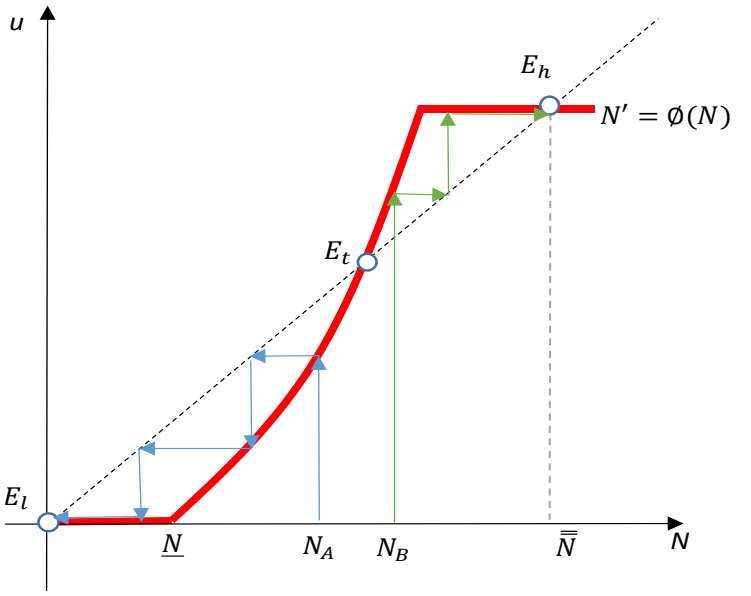
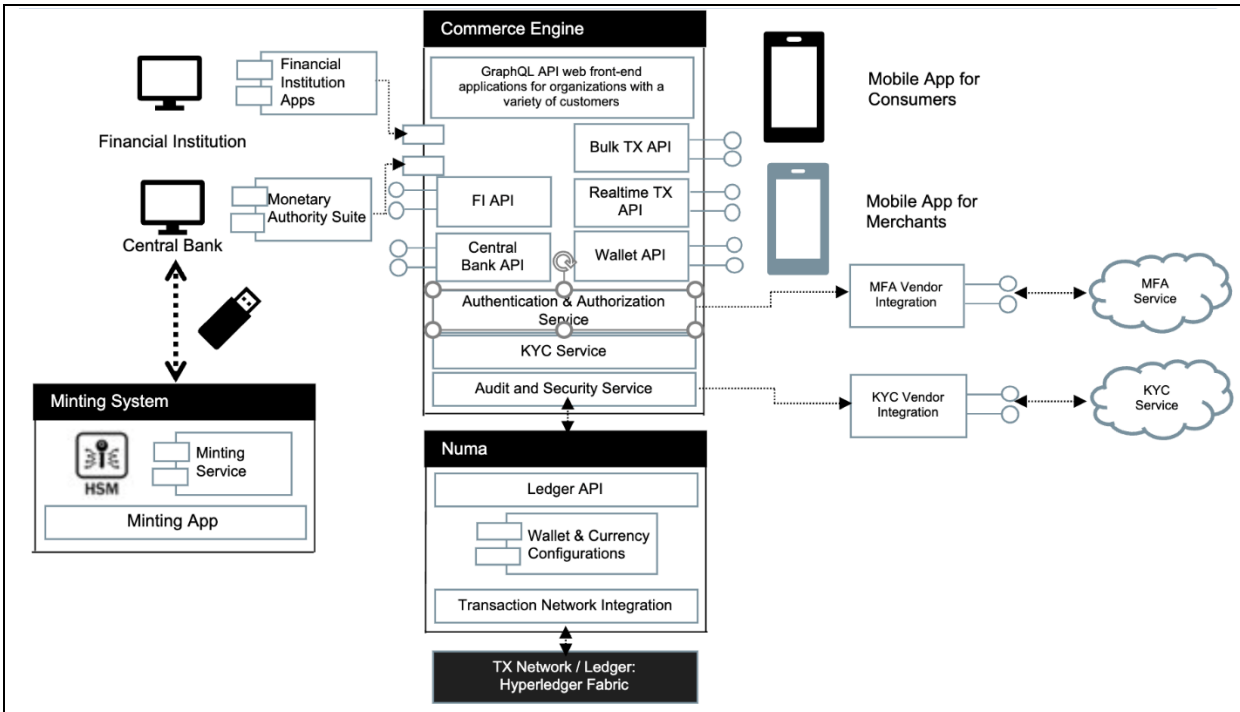


Figure 12 illustrates the point. As is generally the case in fixed point models, the dynamic evolution of the aggregate state N is path dependent and hinges on the starting point. If the starting point $N_A < N_t^*$ then the dynamic transition in the subsequent states drives the equilibrium network size to the low adoption equilibrium E_l. On the contrary, if the starting point $N_B > N_t^*$, the high adoption equilibrium E_h will prevail.

Appendix 1. Digital Currency Management System 1/



Source: Illustration by Bitt Inc provided to the author.

1/ App, API, MFA, KYC, TX stand for application, Application Programming Interface, Multi Factor Authentication, Know Your Customer, and transaction respectively.

Appendix 2. CBDC Questionnaires to CBN

CBDC questions (April 2022)

- ***Q6***: Please provide latest figures on the number of eNiara downloads, and daily transaction value (in naira).

- ***Q7***: Our understanding is that total number of eNaira download is less than one million as of now. Is this speed of adoption in line with your expectation? If the takeoff in eNaira usage is slower than expected, what are the main impediments and what's planned to deal with them?

- ***Q8***: We understand that the next phase of the eNaira project (i.e., expanded coverage to people without bank account and for remittance) will take off in H2 of 2022. Is this still the plan given the slowness in advance of the first phase?

    - We understand that the current plan to allow the use of eNaira for cross border payment entails eNaira's usage for the purpose of remittance. Is there any other forms of cross border payment (e.g., for foreigners' payment of goods exported by Nigerian residents) that is being considered for the expanded usage of eNaira? If so, please elaborate.

    - We understand that to enable eNaira's usage for remittance, the plan is to allow foreign IMTOs in the remittance-source countries (e.g., Western Union in London) to participate in the eNaira network—among others by allowing them to (1) open eNaira wallets of theirs; (2) to onboard remittance senders; who can open eNaira wallets through these IMTOs; and (3) do transactions on eNaira (i.e., buy and sell eNaira). Is this correct? If not, kindly explain the alternative mode of the utilization of eNaira in the remittance procedures (e.g., foreign IMTOs relying on domestic CBDC participants for an access to eNaira; or foreign IMTOs directly participate in eNaira network but need a domestic sponsor bank).

    - If so, would such wallets (i.e., wallet opened by remittance senders through IMTOs) be subject to the same transaction or balance ceilings as eNaira wallets held by Nigerian domestic retail clients? Or will they be subject to different ceilings (or even not subject to any ceilings) considering that remittance transactions could at times be significantly larger than the latter?

    - Would the use of eNaira for remittance require prefunding of eNaira to IMTO's wallets? If not, please explain the envisaged the process through which IMTOs gain access to eNaira.

    - How will the IMTOs determine the exchange rates applied to e-Naira based remittance transactions? Will they be allowed to freely determine the rates based on supply and demand?

    - Would allowing foreign IMTO's participation in eNaira net work require legal/regulatory arrangement with the authorities of the countries of their jurisdiction (e.g., arrangement

between central banks on home supervision, for AML/CFT compliance)?

- Would allowing IMTO's direct or indirect access to eNaira require domestic legal/regulatory amendment? Please explain.

- What AML/CFT related challenges are expected to arise in the second phase eNaira rollout and what's planned to deal with these?

- What's the prospect of offline functionality of eNaira?

- Please comment on the rate of adoption of CBDC payments in the retail sector. What could policies be to allow the population to make purchases via eNaira in brick-and-mortar and internet stores?

- Do you perceive eNaira to be a complement or substitute to other forms of digital money? Do you expect eNaira to replace e-money holdings to a certain extent or rather to also onboard non-users of digital money? To what degree might eNaira benefit financial inclusion, particularly in rural areas with many excluded people?

- Q9: We understand that hyperledger fabric is used as the building block of current eNaira system architecture:

    - Hyperledger fabric is known to use BFT (Byzantine Fault Tolerance) rules for the block validation. Is this the case for eNaira? What is the super majority threshold currently used (e.g., 2/3)?

    - How has the system performed in terms of efficiency (capacity and speed to process mass transaction)? Would a blockchain-based system be able to absorb very large transaction volumes expected to eventually materialize in countries like Nigeria? Please explain.

    - Could a hybrid system between blockchain and host-client models be a solution (as in the case of eYuan) to the efficiency problem? If not, what alternative models can be pursued? Please explain.

    - How has the system performed in terms of cyber security (e.g., temper proof, resilience to hacking or DoS attacks)?

    - Who takes care of user training? Is there a manual and/or a helpdesk?

CBDC questions (October 2022)

- ***Q6***: Please provide latest figures on the number of eNiara downloads, and daily transaction value (in naira).

- ***Q7***: Our understanding is that total number of eNaira download is less than one million as of now. Is this speed of adoption in line with your expectation? If the takeoff in eNaira usage is slower than

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- ***Q8***: We understand that the next phase of the eNaira project (i.e., expanded coverage to people without bank account and for remittance) will take off in H2 of 2022. Is this still the plan given the slowness in advance of the first phase?

    - We understand that the current plan to allow the use of eNaira for cross border payment entails eNaira's usage for the purpose of remittance. Is there any other forms of cross border payment (e.g., for foreigners' payment of goods exported by Nigerian residents) that is being considered for the expanded usage of eNaira? If so, please elaborate.

    - We understand that to enable eNaira's usage for remittance, the plan is to allow foreign IMTOs in the remittance-source countries (e.g., Western Union in London) to participate in the eNaira network—among others by allowing them to (1) open eNaira wallets of theirs; (2) to onboard remittance senders; who can open eNaira wallets through these IMTOs; and (3) do transactions on eNaira (i.e., buy and sell eNaira). Is this correct? If not, kindly explain the alternative mode of the utilization of eNaira in the remittance procedures (e.g., foreign IMTOs relying on domestic CBDC participants for an access to eNaira; or foreign IMTOs directly participate in eNaira network but need a domestic sponsor bank).

    - If so, would such wallets (i.e., wallet opened by remittance senders through IMTOs) be subject to the same transaction or balance ceilings as eNaira wallets held by Nigerian domestic retail clients? Or will they be subject to different ceilings (or even not subject to any ceilings) considering that remittance transactions could at times be significantly larger than the latter?

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  - How has the system performed in terms of efficiency (capacity and speed to process mass transaction)? Would a blockchain-based system be able to absorb very large transaction volumes expected to eventually materialize in countries like Nigeria? Please explain.

  - Could a hybrid system between blockchain and host-client models be a solution (as in the case of eYuan) to the efficiency problem? If not, what alternative models can be pursued? Please explain.

  - How has the system performed in terms of cyber security (e.g., temper proof, resilience to hacking or DoS attacks)?

  - Who takes care of user training? Is there a manual and/or a helpdesk?

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