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## **Central Bank Digital Currencies and the Drex in Brazil**

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# Central Bank Digital Currencies and the Drex in Brazil

May, 2025

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## Abstract

Cryptocurrencies have introduced technological innovations that have transformed financial transactions, based on Distributed Ledger Technology (DLT). DLT ensures transparency and security by recording and synchronizing digital data among network participants, eliminating the need for traditional intermediaries. Central Bank Digital Currencies (CBDCs) emerge as a response to the growing financial digitalization, incorporating these innovations into national currencies to address challenges such as payment efficiency, security, and financial inclusion. This paper examines the proposal by the Central Bank of Brazil to launch the Digital Real (Drex) in a constantly evolving financial environment, driven by innovations like Pix and the expansion of fintechs. The study investigates Drex's potential to improve financial inclusion and the payment system, focusing on reducing operational costs and enhancing security. The research has three main objectives: (1) to classify different CBDC models and their applications; (2) to analyze international experiences with CBDCs, such as the eNaira, JAM-DEX, Sand Dollar, and e-CNY; and (3) to examine the payment system and the state of financial inclusion in Brazil, evaluating Drex's potential impact. Based on a review of CBDC models, international case studies, and an analysis of the Brazilian context, the paper concludes that Drex is likely to have limited impacts on financial inclusion but holds significant potential to enhance the payment system, particularly in the business context, by offering greater efficiency, security, and agility in transactions. Thus, the research contributes to the debate on central bank digital currencies both in Brazil and globally.

**Keywords:** Central Bank Digital Currencies; DREX; Financial Inclusion; Payment System.

## RESUMO

As criptomoedas introduziram inovações tecnológicas que transformaram as transações financeiras, com base na tecnologia de ledger distribuído (DLT). A DLT garante transparência e segurança ao registrar e sincronizar dados digitais entre os participantes da rede, eliminando a necessidade de intermediários tradicionais. As Moedas Digitais do Banco Central (CBDCs em inglês) surgem como uma resposta à crescente digitalização financeira, incorporando essas inovações às moedas nacionais para enfrentar desafios como eficiência de pagamento, segurança e inclusão financeira. Este artigo examina a proposta do Banco Central do Brasil de lançar o Real Digital (Drex) em um ambiente financeiro em constante evolução, impulsionado por inovações como o Pix e a expansão das fintechs. O estudo investiga o potencial da Drex para melhorar a inclusão financeira e o sistema de pagamentos, com foco na redução dos custos operacionais e no aumento da segurança. A pesquisa tem três objetivos principais: (1) classificar diferentes modelos de CBDC e suas aplicações; (2) analisar experiências internacionais com CBDCs, como eNaira, JAM-DEX, Sand Dollar e e-CNY; e (3) examinar o sistema de pagamentos e o estado da inclusão financeira no Brasil, avaliando o impacto potencial da Drex. Com base em uma revisão dos modelos de CBDCs, estudos de caso internacionais e uma análise do contexto brasileiro, o artigo conclui que a Drex provavelmente terá impactos limitados sobre a inclusão financeira, mas tem um potencial significativo para aprimorar o sistema de pagamentos no Brasil.

**Palavras-chave:** Moedas digitais do Banco Central; DREX; Inclusão financeira; Sistema de pagamentos

# 1 Introduction

Cryptocurrencies have introduced technological innovations, such as Distributed Ledger Technology (DLT), which have transformed financial transactions. DLT records transactions in a distributed digital ledger synchronized among network participants, ensuring transparency and security. To validate a transaction, consensus among participants is required. This consensus mechanism eliminates the need for intermediaries to validate transactions, as each transaction is encrypted, ensuring integrity and immutability. DLT also enables the use of smart contracts, which automate processes, reducing costs and speeding up operations. Blockchain is a type of DLT, used in cryptocurrencies such as Bitcoin.

However, cryptocurrencies are speculative in nature and are not backed by central banks, leading to volatility that hinders their use for transactions. To incorporate the functionalities of cryptocurrencies, central banks worldwide are developing digital currencies (CBDCs), which represent an evolution of traditional money by introducing a direct digital form issued by the central bank.

CBDCs are being widely debated globally. According to the BIS 2023 survey on central bank digital currencies and crypto, out of 86 central banks surveyed, 94% are engaged in some form of digital currency (DI IORIO; KOSSE; MATTEI, 2024). As of February 2025, only four CBDCs have been officially launched: Nigeria's eNaira, Jamaica's JAM-DEX, the Bahamas' Sand Dollar, and the Eastern Caribbean Central Bank's D-Cash. Most central banks are still in the research or development phase, with the main challenge being to decide which CBDC model best suits each country's context and the objectives of each central bank.

Based on international literature on CBDC models and the experiences of already launched CBDCs, this article analyzes the proposal of the Central Bank of Brazil (BCB) to launch the Digital Real (Drex) in 2025. Drex emerges in a context of innovation in the Brazilian banking system, driven by the success of Pix (2020) and the growth of fintechs, which have made the financial system more competitive and inclusive. This study assesses the potential of Drex to expand financial inclusion and improve the national payment system.

Besides this introduction, the paper is divided in four sections. Section 2 explores CBDCs, classifying their different types, applications, and economic impacts. Section 3 focuses on international cases of CBDC implementation, analyzing countries that have officially launched their digital currencies, as well as China, which is in an advanced stage of public testing. The motivations, challenges, and economic impacts tailored to each context are highlighted. Section 4 examines the payment system and financial inclusion in Brazil, emphasizing the challenges and opportunities for Drex. This section also discusses the role of innovations such as Pix, fintechs, and mobile banking, along with the technical and economic aspects of Drex's implementation. Finally, the conclusion (Section 5) integrate the analyses developed throughout the study, evaluating Drex's potential to enhance the payment system and promote financial inclusion in Brazil. The main findings, implications, and recommendations for the future of CBDCs in Brazil and the global landscape are also discussed.

## 2 Central Bank Digital Currencies

Currently, the money in circulation within the economy exists in two main forms: physical currency and bank deposits. Physical currency consists of banknotes and coins issued exclusively by the central bank. Bank deposits, on the other hand, are electronic records representing liabilities of financial institutions to households and businesses, essentially constituting a debt of commercial banks that can be converted into physical cash upon request. Thus, although deposits are accessed electronically, they maintain a direct connection with physical money.

With the adoption of CBDCs, the M1 formula can be redefined to include digital currencies. M1 would then be the sum of the cash in circulation (CC), demand deposits, and the available amount of CBDC (SAMPAIO; CENTENO, 2022). The new M1 formula can be expressed as:

$$M1 = CC + \text{Demand Deposits} + \text{CBDC} \quad (1)$$

Similarly, the monetary base, which consists of CC and bank reserves, would also include the amount of CBDC issued to the public. The updated formula for the monetary base would be:

$$\text{Monetary base} = \text{CC} + \text{Bank Reserves} + \text{CBDC} \quad (2)$$

## 2.1 CBDC models

There is no single CBDC model, as its characteristics can vary according to the economic, social, and technological needs of each economy. Different models determine how a CBDC will function and its potential impacts, influenced by its integration with existing payment systems and its ability to support innovations such as programmability and smart contracts (WILMER, 2023; BIS et al., 2021).

One of the primary distinctions is between wholesale and retail use. Wholesale CBDCs are designed for financial institutions, aiming to optimize high-value transactions and improve cross-border payments. Retail CBDCs, on the other hand, are intended for individuals and businesses, focusing on financial inclusion and domestic payment efficiency, enhanced by technologies like smart contracts (BIS et al., 2021; DI IORIO, KOSSE; MATTEI, 2024).

Retail CBDCs can be implemented through three main architectures (BIBI; CANELLI, 2023). In the *direct issuance model*, the central bank issues CBDC directly to users, ensuring trust and security. In the *intermediated issuance model*, the central bank issues CBDC, but distribution is handled by commercial banks, facilitating the transition to digital systems. In the *hybrid model*, the CBDC is an asset of the financial intermediary, meaning it functions as a private currency while the central bank maintains transaction records. This study will not focus on the hybrid model but will instead examine direct and intermediated issuance architectures.

As illustrated in Figure 1, in the case of direct issuance, users hold CBDC accounts directly at the central bank, making it an asset for them and a liability for the central bank, similar to the functioning of physical money.

**Table 1: Direct Architecture**

Central Bank		Users	
Assets	Liabilities	Assets	Liabilities
	CBDC	CBDC	
	\$100	\$100	

Source: Own elaboration.

In Table 2, the central bank issues the CBDC and distributes it to financial intermediaries, such as commercial banks, in exchange for reserves that these institutions hold at the central bank. For users, who can be individuals or businesses, the CBDC becomes accessible through the financial intermediaries, which act as providers of the CBDC. In this relationship, the CBDC appears on the balance sheets of financial institutions as a liability.

**Table 2: Intermediated Architecture**

Central Bank		Financial Intermediaries		Users	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
	CBDC	Reserves	CBDC	CBDC	
	\$100	\$100	\$100	\$100	

Source: Own elaboration.

The implementation of CBDCs is a crucial strategic decision for central banks, with the primary concern being the risk of banking disintermediation. This occurs when deposits migrate to CBDCs, especially in direct issuance models, which can weaken commercial banks and impact monetary policy (INFANTE et al., 2022). Disintermediation can reduce the resources available for credit, increase financing costs, and generate financial instability.

To mitigate these risks, central banks explore strategies such as limits on CBDC holdings and adjustments to the remuneration of digital currencies, making them less attractive than traditional deposits. One proposed solution is a two-tier remuneration system, where interest rates vary depending on the CBDC balance, discouraging excessive holdings and maintaining banking stability (BINDSEIL, 2020).

Cesaratto and Febrero (2023) highlight that the impact of disintermediation depends on the remuneration of CBDCs. Without interest, CBDCs would function as substitutes for physical money, with limited impact. With remuneration, they could attract deposits, forcing banks to raise interest rates, thereby increasing loan costs. Wilmer (2023) warns that disintermediation could occur even without remuneration if CBDCs are seen as safer. The introduction of a CBDC could intensify competition for deposits, pressuring banks to offer more attractive conditions, such as higher interest rates (ANDOLFATTO, 2021; CHIU et al., 2022). Measures such as maximum limits or negative rates could mitigate this, but would reduce the attractiveness of CBDCs.

In a total migration to CBDCs, central banks would adjust monetary policy by controlling interest rates through reserves, altering traditional management. Fernández-Villaverde et al. (2021) emphasize that bank intermediation is essential for the efficient allocation of credit. Banks would compensate for the loss of deposits by borrowing from the central bank or selling assets. Alternatively, the introduction of CBDCs through asset swaps would maintain system stability (WILMER, 2023).

The different retail CBDC models, whether direct or intermediated, or with the possibility of interest remuneration for holders, can result in different economic impacts, presenting both opportunities and challenges. The specific characteristics of these models – use, architecture, limits, yield, and scope of use- -, which generate these impacts, are defined according to the goals that each central bank seeks to achieve with its digital currency (Table 3).



**Table 3: CBDC Models**

Criterion	Options	Description
Use	Retail	Intended for the general public, can be used by individuals and businesses for daily transactions.
	Wholesale	Restricted to financial institutions for interbank settlements, financial market operations, and international transactions.
Architecture	Direct	The Central Bank directly manages user accounts and transactions.
	Intermediated	Financial institutions mediate between the Central Bank and end users.
Limits	With limit	The Central Bank imposes restrictions on the amount that can be held or transacted, avoiding impacts on the banking system.
	Without limit	No restrictions on usage or storage, allowing for complete replacement of physical money and bank deposits.
Yield	Non-remunerated	Functions like physical money, without offering interest on balances held.
	Remunerated	Offers interest, potentially competing with bank deposits and influencing monetary policy.
Scope of use	Domestic	Can be used within the issuing country.
	International	Designed for cross-border transactions, potentially facilitating international payments and reducing remittance costs.

Source: Own elaboration.

## 2.2 Motivations for launching a CBDC

The motivations for launching a CBDC vary between retail and wholesale. For wholesale CBDCs, the main objective is to improve cross-border payments. In contrast, retail CBDCs have distinct motivations between advanced economies (AEs) and emerging and developing economies (EMDEs) (DI IORIO; KOSSE; MATTEI, 2024).

In EMDEs, financial inclusion and the implementation of monetary policies are priorities, whereas in AEs, these issues are less relevant. For both economies, the efficiency of

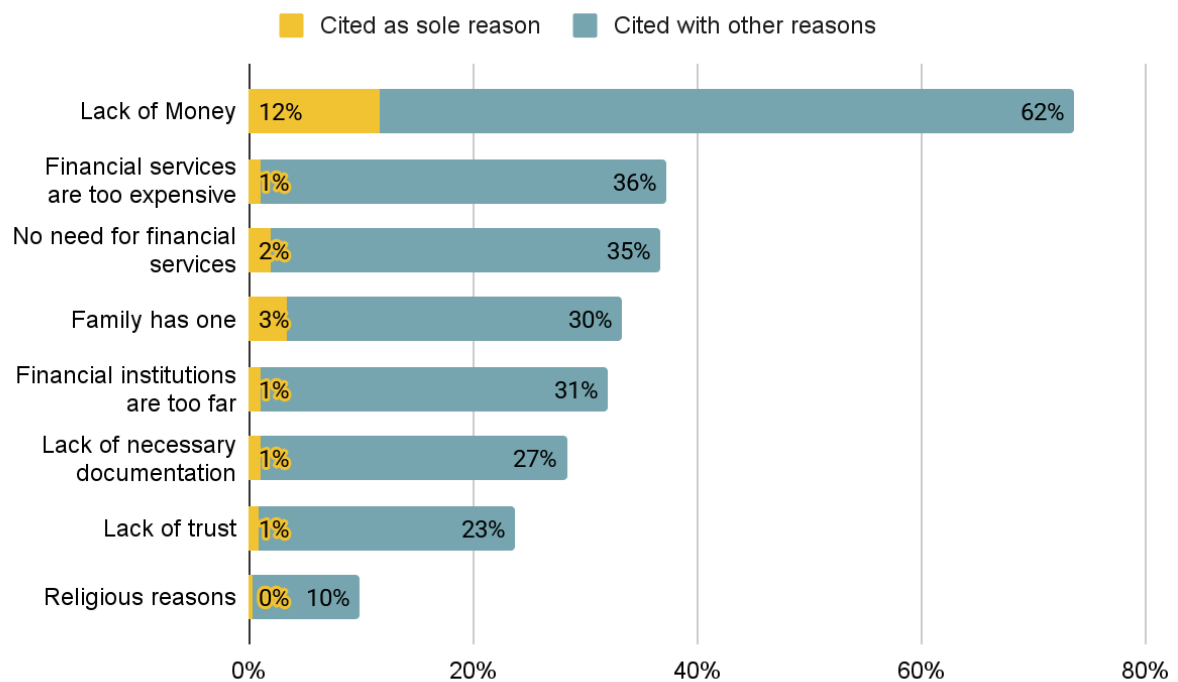
domestic payments, the security and robustness of payment systems, and, to a lesser extent, financial stability are central motivations for retail CBDCs.

Financial inclusion aims to integrate marginalized populations, often tied to the informal economy and dependent on physical cash, into the financial system. Demirgüç-Kunt and Klapper (2012) define financial inclusion as universal access to financial services without barriers. This access allows impoverished individuals to save and gain access to more financial resources, reducing inequalities. Indicators include account ownership, savings, access to credit, and digital payments. Infante et al. (2022) emphasize that financial services increase economic resilience, and a CBDC could facilitate inclusion by reducing costs and eliminating requirements.

Approximately 24% of the global adult population still lacks access to financial institutions, especially in low- and lower-middle-income countries (DEMIRGÜÇ-KUNT et al., 2022). The main barriers include lack of internet access, electronic devices, and bank branches. Additionally, mistrust in banks and concerns about privacy may hinder CBDC adoption. Therefore, its implementation should be accompanied by public policies to expand digital infrastructure and strengthen financial education.

CBDCs could reduce some barriers to accessing the financial system. Figure 1 highlights that the lack of money (62%) is the greatest obstacle to having a bank account, followed by high service costs (36%) and the perceived lack of need (35%). Other factors, such as distance from institutions, documentation, and trust, also influence.

**Figure 1: Reasons cited as barriers to having a bank account at a financial institution worldwide (% of adults without bank accounts in 2021)**



Source: Global Findex Database 2021. Own elaboration.

The CBDC can reduce barriers to financial access by eliminating banking fees and expanding services, especially in remote areas where its digital infrastructure can be accessed via mobile devices (LANNQUIST; TAN, 2023).

However, some of this inclusion may already be achieved by instant payment systems (FPS), such as Pix in Brazil, which allows immediate and free transfers. While FPS operate with bank deposits, CBDCs are digital currency issued by the central bank. In markets with established FPS, the advantage of CBDCs may lie in the ability to conduct offline transactions and reduce costs and financial fees. Thus, their success will depend on the implementation and impact on the efficiency of the financial system.

Regarding payment systems, CBDCs can increase efficiency by reducing transaction time and costs (CESARATTO; FEBRERO, 2023). Their instant settlement via DLT technology provides greater speed and security (PATEL; KASIYANTO; RESLOW, 2024), while digitization reduces expenses related to cash and banking infrastructure.

Although FPS already operates with lower costs, CBDCs can add innovation through smart contracts, automating financial processes and enhancing system efficiency (MITTAL et al., 2024; SCHÄR, 2021).

Moreover, CBDCs can improve interoperability between platforms, promoting standardization of payment systems (INFANTE et al., 2022). The cost structure varies depending on the adopted model: in the direct model, the central bank bears all costs; in the two-tier model, part of the responsibilities is transferred to service providers, which may include regulated fees or exemptions for consumers (PATEL; KASIYANTO; RESLOW, 2024).

Regarding international transactions, wholesale CBDCs can simplify cross-border transactions by reducing intermediaries and high settlement costs, replacing traditional systems like SWIFT with direct transactions between monetary authorities.

Seeking interoperability in CBDC development is vital to avoid fragmentation and strengthen global financial resilience (BIS, 2022). Adopting common technical standards facilitates the connection between national systems or the creation of a single platform for multiple CBDCs (KOSSE; MATTEI, 2022). CPMI (2022) suggests three approaches for interoperability: compatibility, platform interlinking, and a shared single system, the latter being the most efficient in the long term.

Successful CBDC implementation requires international collaboration to overcome legal, technological, and monetary challenges (WORLD BANK, 2021). Besides technical integration, it is necessary to balance operational costs, user privacy, and capital flow control, ensuring a flexible ecosystem that promotes security and competition in the global digital payment system.

Reslow et al. (2024) highlight that CBDCs have the potential to expand cross-border flows, which may, in turn, imply risks related to exchange rate volatility and financial stability. To mitigate these risks, Capital Flow Management (CFM) measures can be automated in CBDCs, making controls more effective and agile.

He et al. (2023) point out that CBDC technology reduces the costs of managing capital flows, traditionally handled by intermediaries. Automation improves efficiency by processing digital information and enables real-time monitoring, applying CFMs automatically when limits are reached. This can minimize errors, enhance regulatory compliance, and, in the long run, make CFMs more cost-effective and efficient.

Several CBDC projects for cross-border transactions are under development, with notable ones including the Dunbar Project, involving the central banks of Australia, Malaysia, Singapore, and South Africa, and the “mBridge Project”, involving China, Saudi Arabia, UAE, Hong Kong, Thailand, and the BIS Innovation Hub. These projects prioritize CBDC interoperability, aiming for more efficient and secure transactions, as well as regulatory compliance, including anti-money laundering measures.

The mBridge, initiated in 2021, seeks to create a multi-CBDC platform for instant payments, reducing costs and promoting financial inclusion. In October 2022, it recorded 164 transactions, totaling U\$22 million, with no intermediaries. By 2024, it had 31 observer members and was advancing interoperability, establishing itself as a model for cross-border payments. Projects like mBridge demonstrate the potential of DLT and smart contracts, but their success requires international cooperation and risk mitigation (BIS, 2024).

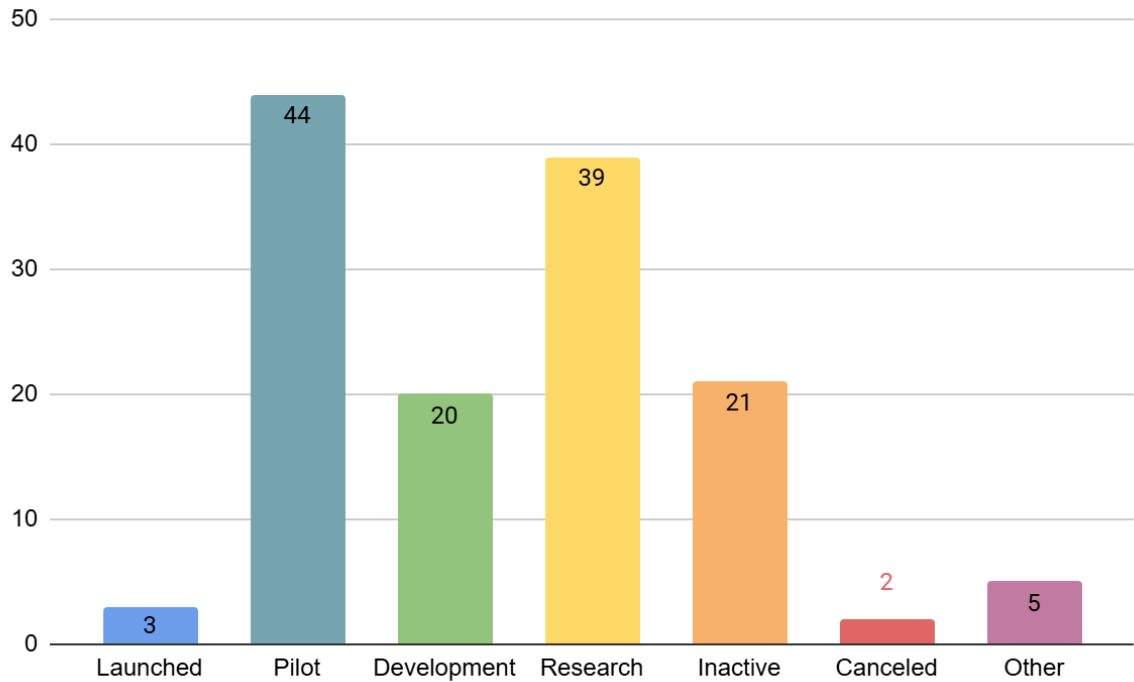
CBDCs offer potential for financial inclusion, payment methods, and international transactions. However, their implementation requires a balance between innovation and financial stability, preventing risks such as banking disintermediation.

### **3 International cases of Central Banks Digital Currencies**

Given the growing interest in CBDCs, this section analyzes the implementation of these currencies in pioneering countries, highlighting objectives, design, challenges, and initial impacts. Through comparative cases, the aim is to understand the approaches adopted and lessons learned. As of December 2024, only three countries had launched CBDCs, while

most were still in assessment or testing phases. According to Kosse and Mattei (2023), 12% of central banks expect to launch a retail CBDC in the next three years, and 16% within six years.

**Figure 2: Development Stage of CBDCs Worldwide**



Source: Atlantic Council – CBDC Tracker data. September 2024 data. Own elaboration.

This section examines the CBDCs already in operation, such as the Sand Dollar (Bahamas), eNaira (Nigeria), and Jam-Dex (Jamaica). Additionally, the study includes the e-CNY, the Chinese digital currency, which is in the pilot phase. The D-Cash, the currency of the Western Caribbean, was launched in March 2021 but was discontinued in 2024 to make way for D-Cash 2.0, and thus will not be included in the analysis. Table 4 summarizes the main goals of the CBDCs in operation.

**Table 4: CBDCs in Operation**

Country	CBDC	Launch	Limits	Accounts	Objectives
Bahamas	Sand Dollar	2020	Limits for users. No limits for merchants	~100,000 (March 2023)	Increase the efficiency of national payment systems, ensure non-discriminatory access to payment systems, promote greater financial inclusion, and strengthen national defenses against financial crimes such as money laundering and counterfeiting, minimizing the negative impacts of using cash.
Nigeria	eNaira	2021	Limits for users. No limits for merchants	~13 million (March 2024)	Increase financial inclusion, boost cross-border transactions, facilitate economic remittances, and complement payment systems.
Jamaica	Jam-Dex	2022	No limits	~260,000 (January 2024)	Modernize the financial system, promote financial inclusion, and reduce reliance on cash.
China	e-CNY	2019 (Pilot)	Limits for users, based on the level of information provided	~180 million (July 2024)	Improve the efficiency, resilience of the central bank payment system, and financial inclusion.

Source: Central Bank of the Bahamas, Central Bank of Nigeria, Bank of Jamaica, and People's Bank of China. Own elaboration.

### 3.1 Sand Dollar

The Sand Dollar, launched in October 2020, was the first CBDC in the world to move beyond the testing phase. The Central Bank of the Bahamas defined four main objectives: increasing payment efficiency, ensuring equitable access, promoting financial inclusion, and strengthening security against financial crimes.

Designed for both wholesale and retail transactions, the Sand Dollar can only be used in the Bahamas through approved e-Wallets. The technology was developed in collaboration

with the companies Movmint and Avertium. A key feature is its ability to operate offline, enabling payments in remote areas and during natural disasters.<sup>1</sup>

To avoid banking disintermediation, there are progressive limits for transactions and balances. Level I has a balance limit of U\$500 and monthly transactions of up to U\$1,500, with no requirement for official identification or a link to bank accounts. Level II allows a balance of up to U\$8,000 and monthly transactions of U\$10,000, requiring official identification and a link to bank accounts. For merchants, wallets have balance limits ranging from U\$8,000 to U\$1,000,000, with unlimited annual transactions, and must be linked to a bank account (CBOB, 2023).

The Sand Dollar operates in an intermediated system, with the Central Bank of the Bahamas responsible for issuing the digital currency, monitoring balances, and managing the centralized identity infrastructure.<sup>2</sup>

Licensed financial intermediaries integrate into the automated clearing system, allowing consumers to conduct transactions, such as real-time direct debits or bank withdrawals, to fund the acquisition of Sand Dollars. The design of the Sand Dollar was planned to ensure interoperability between different digital wallets and intermediaries, enabling users to send and receive the digital currency regardless of the provider.

Between 2020 and 2024, the digital currency of the Bahamas, the Sand Dollar, experienced significant growth, increasing from U\$75,000 in 2020 to an estimated U\$2.38 million in 2024. During this period, the proportion of the Sand Dollar relative to paper money rose from 0.01% to 0.4% (Figure 3). Despite this progress, adoption remains limited. Data from the Central Bank of the Bahamas (2023) indicates that by March 2023, there were 103,148 active wallets, with 101,636 for consumers and 1,512 for merchants, representing about a quarter of the population of approximately 400,000 inhabitants. However, the transaction volume remains low. According to Branch, Ward, and Wright

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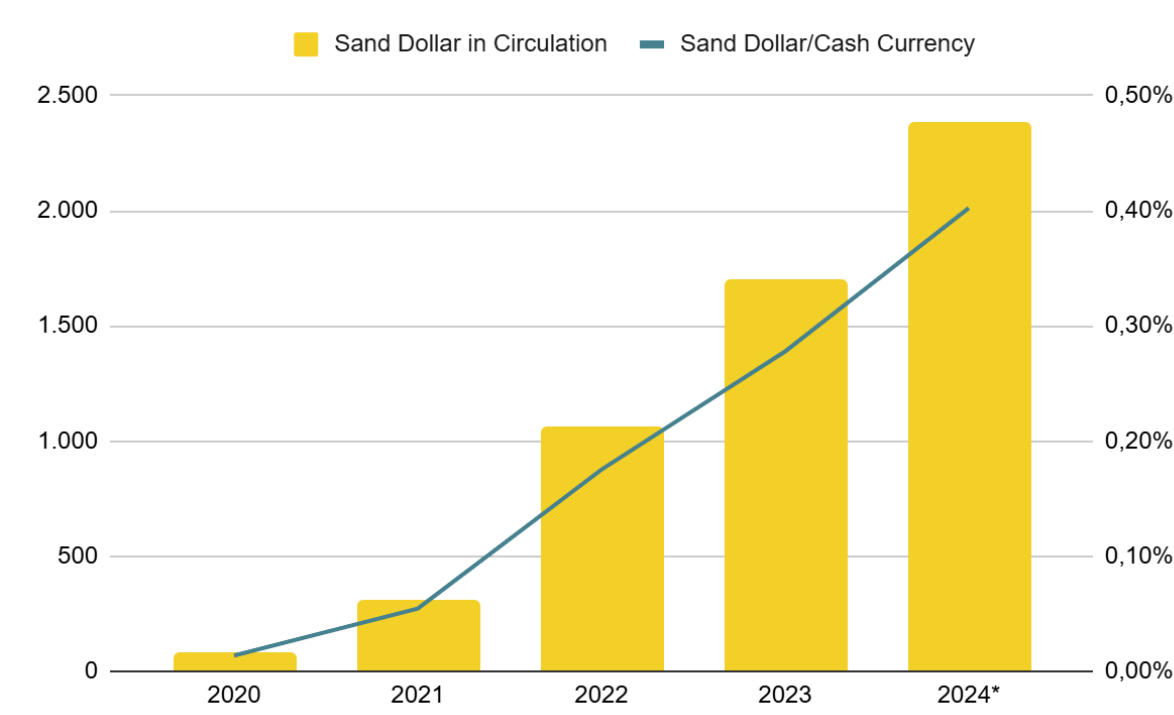
<sup>1</sup> <https://www.sanddollar.bs/about>

<sup>2</sup> <https://www.sanddollar.bs/about>



(2023), the average monthly transaction volume in the country was only U\$85,000 in 2022.

**Figure 3: Sand Dollars in Circulation (Thousands of BSD) and Proportion of Sand Dollar to Paper Money (%)**



\*July 2024

Source: Central Bank of the Bahamas. Own elaboration.

The low adoption of the Sand Dollar results from structural and behavioral challenges. Noll (2024) points out the lack of integration with banks, resistance from financial institutions, and low consumer education as key factors. Furthermore, credit cards still dominate the local financial system, moving 1.77 billion Bahamian dollars in 2023 (CBOB, 2024). Haans (2024) highlights the lack of attractiveness of CBDCs compared to established methods and the absence of clear incentives for users. Minh (2024) adds that financial inclusion is already high in the Bahamas, reducing the impact of the Sand Dollar.

The challenges reveal the need for integrated strategies to overcome institutional and cultural barriers, distinguishing the CBDC from traditional methods. Although it shares similarities with instant payment systems like Pix, the lack of advanced features, such as smart contracts, limits its potential.

### **3.2 eNaira**

The eNaira, the digital currency issued by the Central Bank of Nigeria (CBN), was launched in October 2021, becoming the first officially implemented CBDC on the African continent. Developed with distributed ledger technology by the company Bitt, which also works on D-Cash for the Eastern Caribbean Central Bank, the eNaira follows an intermediated operational model. In this model, the Central Bank issues the digital currency, while authorized financial institutions manage its distribution to individuals and businesses, promoting its integration into the traditional financial system.<sup>3</sup>

The eNaira digital currency features digital wallets with different levels. Level 0 requires only a linked phone number, with a limit of 120,000 nairas. The following levels increase the limits with more stringent requirements, such as proof of residence, reaching up to 5 million nairas at Level 3. Merchants can have unlimited wallets for large businesses and up to 5 million nairas for small businesses. Transactions are fee-free.

The eNaira aims to promote financial inclusion, facilitate cross-border transactions, and complement payment systems. Financial inclusion is crucial in the country, where, in 2021, only 45% of the adult population had a bank account, 13% used cards, and 34% made digital payments (DEMIRGÜÇ-KUNT et al., 2022). These figures highlight the potential of eNaira to broaden access to financial services and drive digitalization.

A key innovation facilitating access to eNaira is the implementation of Unstructured Supplementary Service Data (USSD), a communication protocol used by mobile phones

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<sup>3</sup> <https://enaira.gov.ng/design-paper/>

to connect to mobile network operators' systems. This technology was implemented in August 2022 and allows eNaira to be used offline and without the need for a smartphone, requiring only a basic mobile phone. This is particularly relevant in a context where only 25% of the Nigerian adult population has internet access, but 73% own some type of mobile phone (DEMIRGÜÇ-KUNT et al., 2022).

Despite advantages such as the ability to access the digital financial system without a bank account, using only a phone number, and making transactions without additional costs, public adoption of eNaira has been low. According to Ephraim, Ozioma, and Ejodamen (2023), the USSD channel is not widely known by the population.

According to Ree (2023), by the end of November 2022, there were about 860,000 retail eNaira wallets, representing only 0.8% of the active bank accounts in Nigeria, while merchant wallets totaled 100,000. Most wallets are inactive, with an average of 14,000 weekly transactions from the launch until November 2022, equivalent to only 1.5% of the total wallets. This means that 98.5% of the wallets are not used weekly.

According to the Central Bank of Nigeria's Quarterly Statistical Bulletin for the first quarter of 2024, the total amount of eNairas in circulation at the end of March 2024 was 13.98 billion (equivalent to 56 million reais in December 2024), which represents 0.36% of the currency in circulation in the country (CBN, 2024). Adoption of eNaira faces significant challenges. One factor contributing to the low adoption of the digital currency is the negative impact of accelerated inflation, worsened by the depreciation of the naira. The accumulated inflation for 2024 was 34.8%, discouraging people from investing money in an instrument like eNaira that does not yield interest.

The lessons learned from the eNaira case suggest that the success of a CBDC in developing economies depends on its implementation according to local conditions, such as low connectivity, economic informality, and low digital literacy. Overcoming these barriers requires financial education campaigns, incentives to use eNaira for social transfers, wages, and taxes, as well as policies to expand digital and financial access, especially in vulnerable regions.

Initiatives like USSD show potential but require education and awareness to maximize their impact. Moreover, building trust in the system is crucial in contexts of institutional distrust. The Nigerian example reinforces that an effective CBDC requires not only technology but also integrated public policies, infrastructure improvements, and incentives for use in essential services and government programs.

### **3.3 Jam-Dex**

The Jamaica Digital Exchange (Jam-Dex) is the CBDC launched by the Bank of Jamaica (BOJ) in July 2022, developed in partnership with the company eCurrency. The adopted model is intermediated, meaning that the BOJ issues the digital currency, but the management of wallets is carried out by intermediaries, such as commercial banks and authorized financial institutions through an app.

To create a digital wallet for Jam-Dex, users need to provide basic information, such as a valid identification document and address. There is no need to have a bank account to use it, allowing unbanked individuals to participate in the formal financial system. According to the Findex Database 2021, 27% of the population aged 15 years and older does not have a bank account, highlighting its potential for financial inclusion. Deposits into the CBDC wallet can be made in various ways, including directly at ATMs, through bank apps, or at service points of authorized financial intermediaries.<sup>4</sup>

According to the Bank of Jamaica (BOJ), the main objectives of the Jam-Dex include modernizing the financial system by promoting digital transactions, enhancing financial inclusion, and reducing costs for users and the financial system, with the absence of transaction or wallet maintenance fees.

By July 2022, one month after its launch, Jam-Dex had already registered around 120,000 active digital wallets. This result was boosted by a BOJ campaign that offered a financial

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<sup>4</sup>See <https://boj.org.jm/core-functions/currency/cbdc/cbdc-faqs/>

incentive of 2,500 Jamaican dollars (approximately 100 Brazilian reais in December 2024) to the first 100,000 people who created their digital wallets (JAMAICA OBSERVER, 2022). On February 18, 2023, the total number of Jam-Dex users had reached 190,000, including 185,410 individuals, 90 small merchants, and 4,500 micro-merchants. To further boost adoption, the BOJ launched a new campaign in April 2023, offering 25,000 Jamaican dollars (approximately 987 Brazilian reais in December 2024) to the first 10,000 merchants who created a Jam-Dex wallet (PATTERSON, 2023).

Despite the BOJ's campaigns to encourage the adoption of Jam-Dex, the country's digital currency has not achieved widespread use. According to BOJ data, by January 2024, 260,000 digital wallets had been created, accounting for about 9% of the population. In February 2024, 257 million Jam-Dex were in circulation (around 10 million Brazilian reais in December 2024), indicating low usage of these accounts (LEDGER INSIGHTS, 2024).

The limited adoption by merchants is a significant obstacle. Despite the BOJ's incentives, integration has been slow due to technical challenges and a lack of compatibility with existing payment systems. Currently, only 2,379 merchants accept Jam-Dex. Moreover, commercial banks show little interest in promoting it, reducing competition and inhibiting innovation. This highlights the need to align incentives and engage financial institutions in the adoption of the CBDC.

One of the main obstacles to the adoption of the CBDC in Jamaica is the dominance of cash-based transactions. Currently, around 80% of transactions in the country still rely on paper money. The Jam-Dex case highlights the challenges of implementing a CBDC. Initial financial incentives do not guarantee sustainable adoption, which depends on trust, convenience, and perceived benefits. The strong dependence on cash makes the acceptance of digital currency difficult, turning the process into a gradual one that requires continuous efforts to overcome structural, cultural, and institutional barriers. Integrated and well-planned strategies are essential to achieve long-term benefits.

### 3.4 e-CNY

The e-CNY, or Digital Yuan, is China's official digital currency developed by the People's Bank of China (PBoC). Currently, the project is in its pilot phase, being gradually expanded to different regions of the country. The pilot program began in 2019 with tests in four cities: Shenzhen, Suzhou, Xiong'an, and Chengdu. Since then, the scope has been expanded to include major cities like Beijing, Shanghai, and Chongqing. By December 2022, the pilot had reached 29 cities, allowing a significant portion of the population to access the e-CNY.

The official e-CNY app was publicly launched on January 4, 2022, for residents of the participating cities. Later, in February 2022, during the Beijing Winter Olympics, the app became accessible to foreigners, facilitating access for international visitors to China's payment system (WALICZEK, 2023).

According to Mu (2023), the PBoC aims to achieve several objectives with the e-CNY, including increasing the efficiency and resilience of the central bank's payment system, promoting financial inclusion, especially for rural populations or those without internet access, facilitating cross-border transactions to make the system more accessible to foreigners, reducing reliance on private platforms like WeChat Pay and Alipay for financial transactions, and simplifying payments in a context where the use of physical cash is declining.

The e-CNY operates on a two-tiered intermediary model: the PBoC issues the digital currency, and financial institutions distribute it to the public, maintaining 100% reserves at the central bank. One advantage of the e-CNY is the ability to make offline payments, facilitating inclusion in areas with limited internet access (WALICZEK, 2023).

Another attractive feature of the e-CNY is that there are no transaction or account maintenance fees. According to the World Bank's Global Findex Database 2021<sup>5</sup>, 76% of the Chinese population aged 15 and older used a mobile phone or the internet to make

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<sup>5</sup> <https://www.worldbank.org/en/publication/globalfindex/Report>

payments, purchase items, or send or receive money using a financial institution account. Most of these payments are concentrated in the WeChat Pay app from Tencent Group and Alipay from Ant Group. In 2024, Alipay had 1.26 billion users, and WeChat Pay had 1.05 billion users.<sup>6</sup> However, Alipay and WeChat Pay charge transaction fees for merchants, ranging from 0.55% to 0.6%, which are not high compared to traditional credit card fees, but still generate costs for users.

The digital wallet system of the e-CNY is organized into four levels, with different degrees of functionality and financial limits, based on identification requirements. At Level 4 (Anonymous): Only requires a phone number linked to a Chinese ID, with a balance limited to 10,000 RMB and transactions up to 2,000 RMB per operation. At Level 3: Requires national ID and local registration, allowing a balance of up to 20,000 RMB and transactions up to 5,000 RMB. At Level 2: Requires a personal bank account, raising the limits to a balance of 500,000 RMB and daily transactions up to 100,000 RMB. At Level 1 (No limits): Requires in-person registration and full association with a bank account, removing financial restrictions (MU, 2023).

According to data from the PBoC, by July 2024, the e-CNY app had 180 million digital wallets, with a total volume of 7.3 trillion RMB (about 6.2 trillion Brazilian reais converted in December 2024) in pilot areas since the start of operations. Additionally, the digital currency advanced in the use of smart contracts, processing 346,000 transactions totaling 57 billion RMB (about 48 billion Brazilian reais converted in December 2024). According to the PBoC, the money in circulation (M0) in November 2024 was 12.4 trillion yuan (about 10.5 trillion Brazilian reais in December 2024).

The adoption of e-CNY faces challenges due to strong competition from Tencent and Alibaba, which operate WeChat Pay and Alipay, respectively. These companies offer super apps that integrate various services, including social media, banking, digital shopping, and payments, creating a highly attractive ecosystem for users. So far, e-CNY does not present significant advantages over these private systems, which does not create

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<sup>6</sup> <https://www.statista.com/statistics/1271130/mobile-wallet-user-forecast-in-china/>

incentives for its large-scale adoption. Many consumers do not see clear benefits in using the state digital currency in their daily lives.

The e-CNY is still in the testing phase, concentrated in large urban centers, without reaching regions with greater potential for financial inclusion. Although incentive projects have shown some success, more strategies will be needed to ensure its continued use (MU, 2023).

However, on the international front, e-CNY shows promising potential. It is part of the mBridge (Multiple CBDC Bridge) initiative, a collaborative project between the People's Bank of China, the Hong Kong Monetary Authority, the Bank of Thailand, and the Central Bank of the UAE, with support from the Bank for International Settlements. mBridge aims to establish a multilateral platform for cross-border settlement using the CBDCs of these respective countries, in order to reduce costs, increase efficiency, and decrease reliance on traditional intermediaries in global trade.

## **4 Brazilian case: The Drex**

Based on the lessons drawn from the literature on CBDCs discussed in section 2 and the practical cases of countries that have already implemented CBDCs, analyzed in section 3, this section explores the potential of the Digital Real for the Brazilian economy, considering the model currently developed by the Central Bank of Brazil.

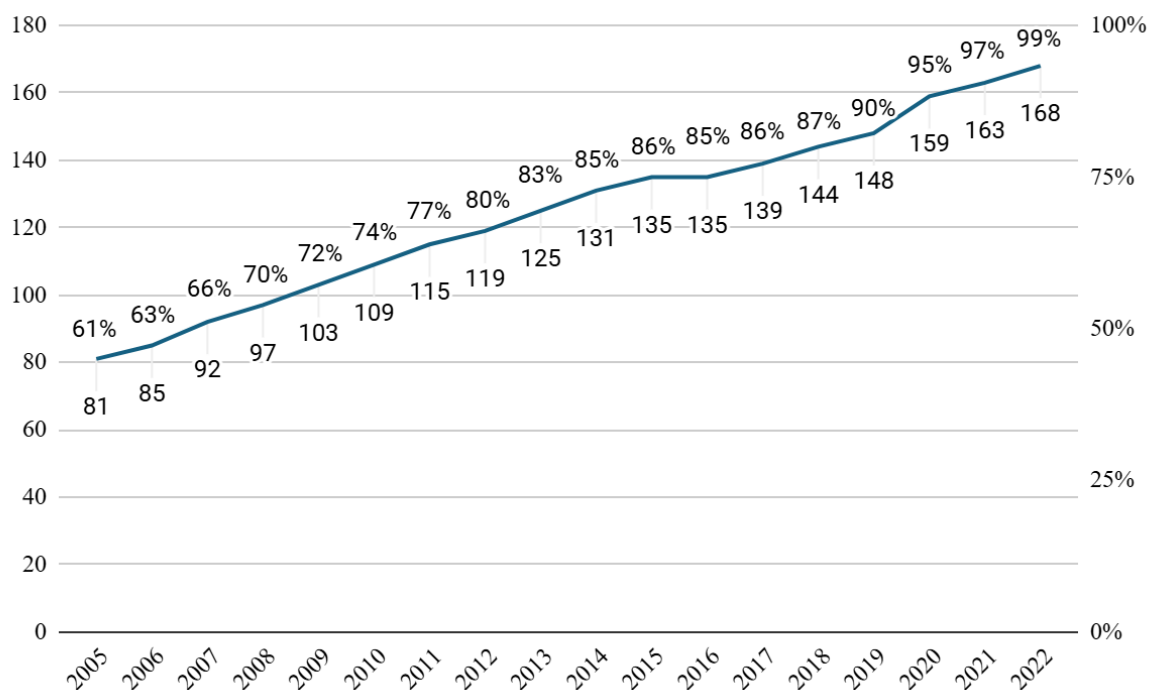
According to the BCB (2023), the issuance of Drex has the following objectives: (1) To keep pace with the dynamic technological evolution of the Brazilian economy; (2) To increase the efficiency of the retail payment system; (3) To contribute to the emergence of new business models and other innovations based on technological advancements; (4) To enhance Brazil's participation in regional and global economic scenarios, improving efficiency in cross-border transactions; (5) To deepen financial inclusion in Brazil, democratizing access to services such as investments, financing, and insurance.



## 4.1 Financial Inclusion in Brazil

According to the Central Bank of Brazil, financial inclusion consists of effective access to the following financial services provided by formal institutions: credit, savings, payments, insurance, pensions, and investments. As shown in Figure 4, the number of adults with banking relationships in Brazil increased from 81 million in 2005 (61% of the adult population) to 168 million in 2022 (99% of the adult population).<sup>7</sup>

**Figure 4: Number and percentage of adults with banking relationships<sup>8</sup> - Brazil (millions). 2005 to 2022**



Source: BCB-Depef. Own elaboration.

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<sup>7</sup> <https://www.bcb.gov.br/cidadaniafinanceira>

<sup>8</sup> Adults with banking relationships: This refers to individuals over the age of 15 who hold deposit accounts or financial assets in the form of goods, rights, and values, maintained or managed by commercial, multiple-service, investment banks, and savings banks. It considers only one CPF (Brazilian individual taxpayer registry number), even if the customer has more than one banking relationship. It does not include customers who only have credit operations.

The increase in the number of bank accounts does not guarantee access to services such as credit, savings, and insurance, but it is an important step toward financial inclusion. This growth was mainly driven by the emergence of fintechs, emergency income aid during the pandemic, and the creation of Pix.

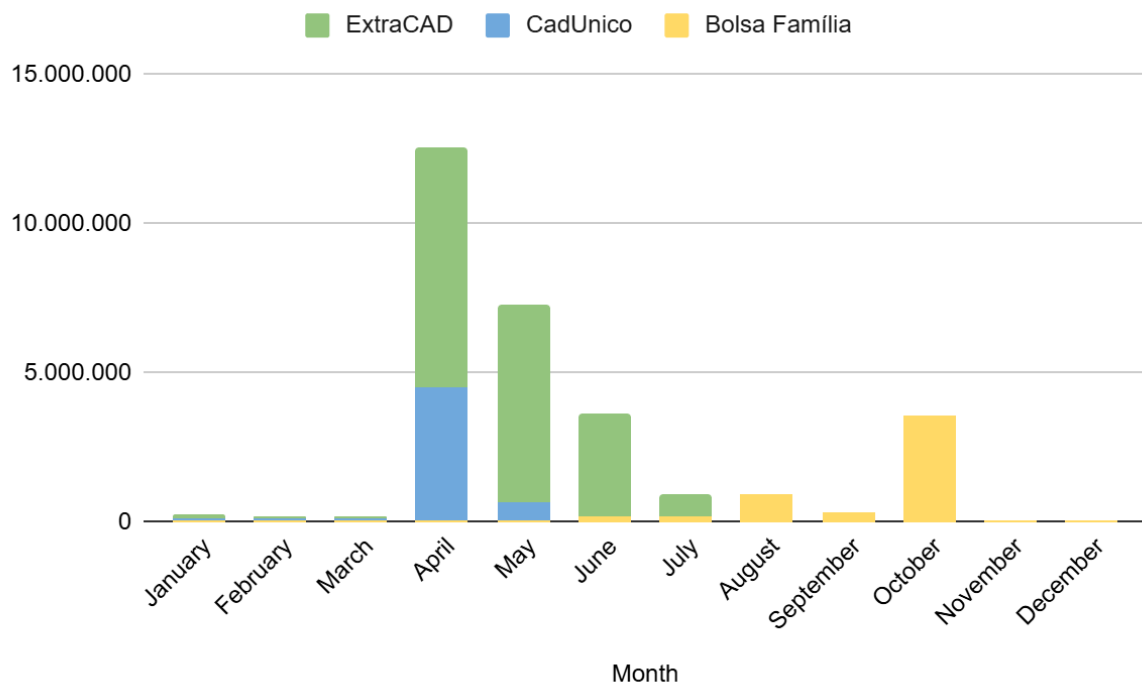
Fintechs, by operating entirely digitally, reduced costs and eliminated the need for physical branches, offering services such as account openings and transfers with lower or waived fees. They also boosted financial inclusion by providing services via the internet and apps, expanding banking access and intensifying competition in the sector.

According to the 2021 Financial Citizenship Report, internet access grew from 57% in 2013 to 81% in 2020, and mobile phone ownership increased from 77.4% in 2016 to 87.6% in 2023 (PNAD TIC). Mobile banking, combined with greater accessibility to mobile devices and the internet, enabled banking services to reach previously excluded populations. According to the Febraban Survey, bank accounts with mobile access grew from 29% in 2016 to 64% in 2019 (BARROSO, 2020), becoming the main driver of bank account growth.

In addition to fintechs, the Emergency Aid during the pandemic year of 2020 had a significant impact on banking inclusion by encouraging the opening of accounts and expanding access to the financial system for vulnerable populations.

We can see in Figure 5 that between April and October 2020, approximately 29 million new accounts were opened exclusively for receiving Emergency Aid. The Emergency Aid, launched in April 2020, offered a monthly benefit of R\$ 600 to informal workers, freelancers, and the unemployed, making a significant contribution to financial inclusion in the country (PAULA, 2021).

**Figure 5: New accounts created for Emergency Aid payments, by beneficiary classification (Jan to Dec 2020)**



Source: Financial Citizenship Report 2021. Own elaboration.

The year 2020 was marked by a transformation in access to banking services in Brazil, driven by the launch of Pix. Developed by the Central Bank, the instant payment platform promoted financial inclusion, enabling more than 50 million people to make their first bank transfer in its first year of operation (LANNQUIST and TAN, 2023).

Pix offers instant transfers 24 hours a day, with no fees for individuals. For legal entities, fees range from 0.99% to 1.45% of the transaction value, with minimum fees of 1 real and a maximum of 10 reais. This system revolutionized the market by contrasting with traditional methods like DOC, TED, and bank slips which involved high fees, restricted hours, and slower processing. Before Pix, many Brazilians, especially low-income individuals, depended on cash to carry out most of their transactions.

The convenience and zero-cost nature of Pix encouraged financial formalization, increasing the opening of bank accounts, especially among informal traders and small entrepreneurs. Additionally, Pix benefited consumers with immediate peer-to-peer

payments, enhancing transaction security, reducing reliance on financial intermediaries, and boosting the digitalization of the Brazilian economy.

Pix experienced significant growth during its first four years, reaching over 816 million keys by December 2024. The number of users registered in the Directory of Identifiers of Transactional Accounts (DICT) in the same month was 171.5 million. In November 2024, the number of Pix transactions totaled 5.8 billion, with a total value of 2.49 trillion reais. Therefore, the implementation of Pix led to a significant increase in the proportion of Brazilians with access to banking services, especially benefiting less developed regions of the country where the presence of bank branches is limited.

Although Brazil has made considerable progress in banking inclusion, with a large part of the population having access to bank accounts, the current challenge is to promote the use and diversification of financial services. Therefore, DREX should focus on making services such as credit and insurance more accessible by lowering costs and offering new solutions.

## **4.2 Brazilian Payment System**

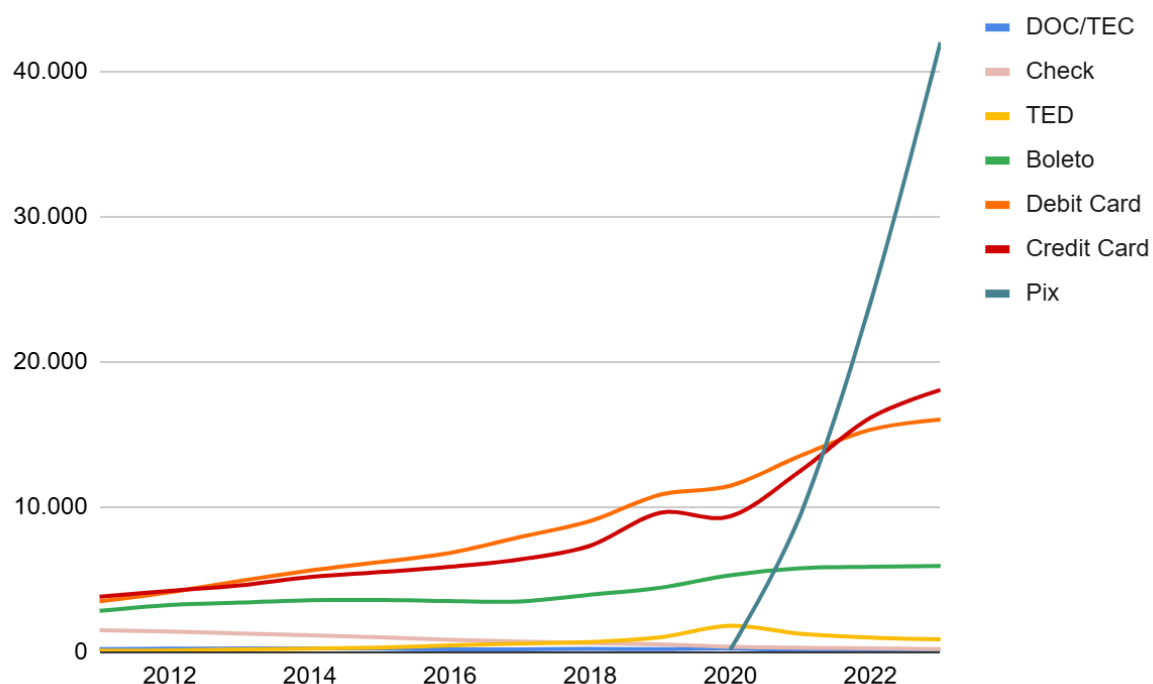
The Brazilian Payment System (SPB) is internationally recognized for its modernity, driven by banking automation. Starting in the 1970s, restrictions on the import of computers led the banking sector to develop its own technologies, supporting local innovation and enabling fast data processing (CARVALHO et al., 2010). This advancement was accelerated by the high inflation of the 1980s and 1990s, which required agile solutions in the payment system to mitigate monetary devaluation.

Banks invested in proprietary technologies, consolidating an efficient financial system capable of handling large volumes of transactions and reducing costs. Recently, the launch of Pix transformed the SPB, driving financial inclusion with instant payments and low costs.

Figure 6 shows a transformation in payment methods in Brazil, with traditional methods being replaced by more modern alternatives. Bank checks dropped from 1.5 billion

transactions in 2011 to 221 million in 2023, while DOCs (credit order document) and TECs (special credit transfer) - type of bank transfer that allows customers to send money from one bank to another - were largely replaced by TEDs (bank transference in 1 hour), which grew from 113 million transactions in 2011 to 1.8 billion in 2020. However, Pix (immediate bank transference), launched in 2020, surpassed these methods, jumping from 176 million transactions in its first year to 41.98 billion in 2023. credit order document and Special Credit Transfer. This growth in the use of Pix without a corresponding reduction in other payment methods reflects an increase in digital transactions.

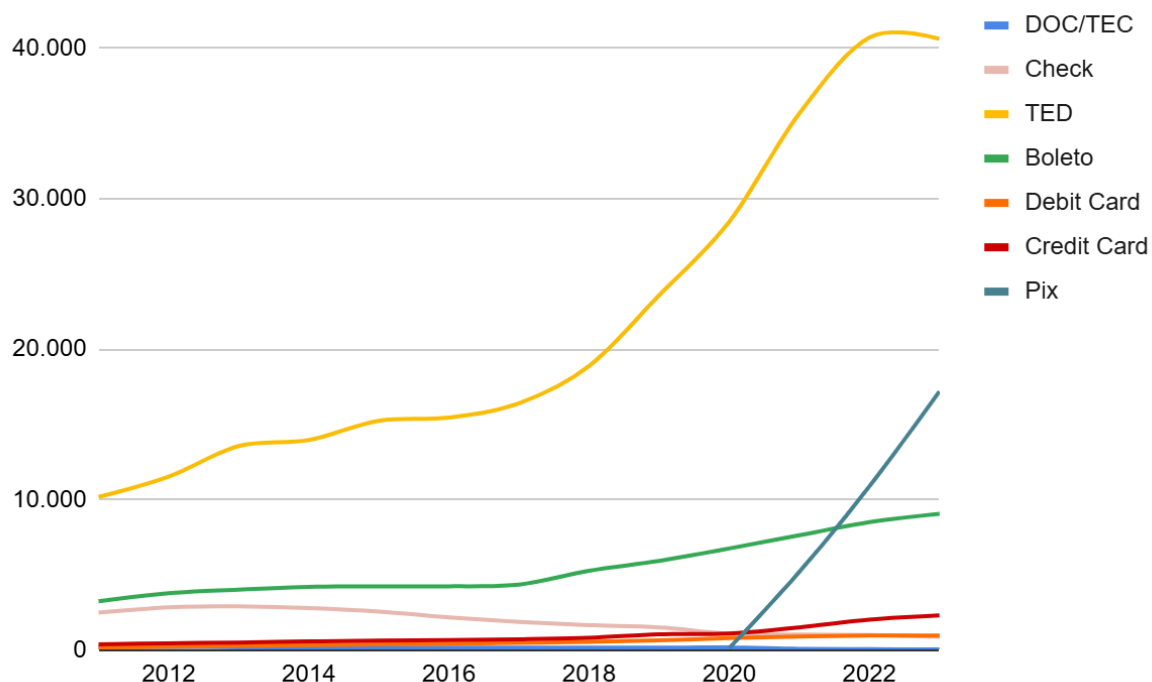
**Figure 6: Number of Transactions (millions). 2011 to 2023**



Source: BCB - Payment Instruments 2023. Own elaboration.

However, as can be seen in Figure 7 in terms of value, TED continues to move more resources. The value processed by Pix increased from 150 billion reais in 2020 to 17.19 trillion reais in 2023. However, Pix has not yet surpassed TED in financial volume; TED maintained a growth trajectory, rising from 10.2 trillion reais in 2011 to 40.6 trillion reais in 2023.

**Figure 7: Value of Transactions (R\$ billions). 2011 to 2023**



Source: BCB - Payment Instruments 2023. Own elaboration.

Companies and financial institutions tend to use TED for higher-value transactions, while Pix is widely adopted by consumers for everyday payments. The average ticket for TED is significantly higher, around R\$ 46,000, while the average ticket for Pix in 2023 was around 400 reais.

TED, which stands for Available Electronic Transfer, can only be made until 5 p.m. on business days. After this time, the transfer can be scheduled for the next business day or a later date.<sup>9</sup> Additionally, the cost of TED can be high, reaching up to R\$ 25 per transaction. In this context, one of the main challenges in the evolution of the payment system is to develop alternatives that overcome the limitations of these more expensive and less agile methods.

<sup>9</sup> <https://www.bcb.gov.br/meubc/faqs/p/o-que-e-transferencia-eletronica-disponivel-ted>

It is in this scenario that Drex should play a role in improving the payment system. Its role should complement Pix, offering cost reduction and increased efficiency for transactions that still rely on TED or other less efficient methods. This can be achieved through the implementation of smart contracts and specific functionalities for business transactions, making transfers faster, cheaper, and more secure.

### **4.3 Drex**

The Central Bank of Brazil is currently in the pilot phase for the launch of Drex. The name combines the letters "d" and "r," representing the Digital Real, with "e" symbolizing the electronic aspect of the currency and "x" referring to the idea of connection, following a similar logic to the concept of Pix. On January 1, 2025, the first Drex transfer took place between Caixa Econômica Federal and Banco Inter.

According to Araújo (2022), Drex will utilize distributed ledger technologies, enabling advanced functionalities such as programmable money and smart contracts. Its distribution structure will be made in two levels: the Central Bank will be responsible for issuing the digital currency, while financial institutions and other payment system participants will offer access to Drex for end-users. This model integrates existing institutions into the system, which may facilitate usability.

To access the platform, users will need an authorized financial intermediary, such as a bank, that converts balances in reais to digital balances within the Drex Platform. This conversion allows transactions with digital assets, such as the purchase of tokenized real estate. An important characteristic of Drex is that it will not be a remunerated instrument, meaning it will not accrue interest. This decision reflects the Central Bank's intention to avoid using the currency as a monetary policy tool, focusing its applications on retail uses.

The key differentiator of Drex is its programmability and automation, which sets it apart from other financial technologies like cryptocurrencies. Drex will operate within a regulatory framework, enabling the concept of "supervised automation." In this model,

automation and programmability coexist with control and supervision by the Central Bank, as highlighted by Sanches and Diniz (2023).

With the adoption of this smart contract functionality, there is the possibility of automatic execution of contracts when predefined conditions are met. This mechanism verifies if all contractual conditions have been fulfilled, such as the transfer of ownership of an asset. After this verification, the bank transfers the digital currency from the buyer's wallet to the seller's wallet and the seller's asset to the buyer.

On September 4, 2024, the Central Bank of Brazil (BCB) and the Securities and Exchange Commission (CVM) announced 13 projects selected for the second phase of Drex Pilot testing. This phase is scheduled to be completed by mid-2025 and aims to test the implementation of smart contracts integrated with Drex.

Examples of smart contract applications include Receivables Assignment, which facilitates the movement of amounts businesses are entitled to receive from credit card transactions between commercial establishments and their suppliers; Collateralized Credit, which allows users to use assets, such as Certificates of Deposit or government bonds, as collateral for loans, thereby reducing risks and, consequently, the costs associated with credit; and Real Estate Transactions, which enable the automatic transfer of property ownership as soon as the buyer's payment is made, eliminating the need for intermediaries, such as notaries.

In general, these solutions are more geared toward the business environment. Smart contracts, by their nature, involve transactions that are not part of the daily routine of most people, such as real estate or automobile transactions. Therefore, the direct impact of Drex on financial inclusion may be limited, depending on the digital currency's ability to provide services previously unavailable to the financially excluded population.



## 5 Conclusion

This paper sought to understand the main challenges and opportunities presented by CBDCs. There is a growing global interest in the adoption of central bank digital currencies, which could reshape the financial system and improve payment efficiency. However, it also became clear that the implementation of CBDCs faces several obstacles that require careful planning and a critical analysis of the economic, institutional, and technological conditions of the countries involved.

Although CBDCs hold potential, the analysis of international experiences shows that the results of their implementation have been, so far, limited. Countries such as the Bahamas, Nigeria, Jamaica, and China, which have already launched their own digital currencies, have faced slower adoption than expected by the population. Among the main obstacles is the lack of clear incentives for the use of these new forms of currency. The CBDCs launched so far have mostly been limited to replicating the characteristics of physical money, without fully exploring the potential of innovations suggested by the literature, such as the use of smart contracts.

The experience of PIX in Brazil boosted financial inclusion and payment methods, and DREX could represent a new breakthrough, especially for the business sector. With smart contracts and financial automation, DREX can increase the efficiency and security of transactions. Its direct impact on consumers may be limited, but for businesses, the benefits are significant, promoting innovation. DREX can place Brazil at the forefront of CBDCs, encouraging new financial solutions based on DLT technology. Furthermore, its greatest potential may lie in transforming international transactions and reducing reliance on private intermediaries, although this advance is more complex and time-consuming.

In summary, this paper aimed to contribute to the debate on the future of Central Bank Digital Currencies, with an emphasis on the Brazilian context. Its greatest potential may lie in transforming international transactions, reducing dependence on private intermediaries. However, advancements in this area are more complex and time-consuming.

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