



## A Review of Central Bank Digital Currency: Current Status and Changing Trends

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### Abstract

Since the emergence of the Central Bank Digital Currency (CBDC), which digitally represents the legal currency of the country in which it is created, significant developments have been experienced in the global financial environment as a result of the changes brought about by the innovations. Although CBDCs offer various advantages, such as cost reduction, financial inclusion, and increasing the efficiency of payment systems, they may create some disadvantages, such as the risk of dysfunctionalization of the banking sector or decreasing the level of security. At this point, it is necessary to be aware of the possible risks it may create and to develop an optimum strategy in case such risks arise to establish a successful CBDC system and benefit from its advantages. In this context, the aim of this study is to analyze all aspects (emergence process, positive/negative sides, projects, use cases, and technical infrastructure to be used) of this digital currency and to make a comprehensive evaluation of CBDC applications around the world. The evaluations show that many countries are not indifferent to this new digital currency, which has a very high development potential, and continue their research intensively in order not to fall behind the steps taken in CBDC.

**Keywords:** Central bank digital currency, digital money revolution, international financial system, blockchain technology

**Jel Codes:** E50, E58, G15, O31, O33

## Merkez Bankası Dijital Para Birimi Üzerine Bir Araştırma: Mevcut Durum ve Değişen Eğilimler

### Özet

Oluşturulduğu ülkenin yasal para birimini dijital olarak temsil eden Merkez Bankası Dijital Para Birimi'nin (CBDC) ortaya çıkışından bu yana, yeniliklerin getirdiği değişimler sonucunda küresel finans ortamında önemli gelişmeler yaşanmıştır. CBDC'ler maliyetlerin azaltılması, finansal kapsayıcılık ve ödeme sistemlerinin etkinliğinin artırılması gibi çeşitli avantajlar sunmakla beraber bankacılık sektörünün işlevsizleşmesi riski ya da güvenlik seviyesinin düşmesi gibi bazı dezavantajlar da yaratabilmektedir. Başarılı bir CBDC sisteminin kurulması ve potansiyel avantajlardan faydalanılması noktasında ilgili sistemin yaratabileceği olası risklerin farkında olunması ve bu risklerin ortaya çıkması durumunda optimum bir strateji geliştirilmesi büyük önem arz etmektedir. Bu bağlamda çalışmada ilgili dijital para biriminin tüm yönlerinin (ortaya çıkış süreci, olumlu/olumsuz yanları, projeler, kullanım alanları, kullanılacak teknik altyapı) analiz edilmesi ve dünyadaki CBDC uygulamalarının kapsamlı bir değerlendirmesinin yapılması amaçlanmaktadır. Yapılan değerlendirmeler, birçok ülkenin gelişme potansiyeli oldukça yüksek olan bu yeni dijital para birimine karşı kayıtsız kalmadığını ve CBDC konusunda atılan adımların gerisinde kalmamak için araştırmalarını yoğun bir şekilde sürdürdüğünü göstermiştir.

**Anahtar kelimeler:** Merkez bankası dijital para birimi, dijital para devrimi, uluslararası finansal sistem, blokzincir teknolojisi

**Jel Kodu:** E50, E58, G15, O31, O33

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## 1. INTRODUCTION

The form of money has changed with the change in human needs and economic activities. By the end of the era of physical money, commercial banks had focused on several innovations, such as deposit money, electronic funds transfer (EFT), credit cards, and mobile banking. The ubiquity of banks, the prevalence of electronic money, and the near obliteration of physical money are about to eliminate the difference between digital money and real physical money. Today, there is also a shift toward software-based transactions, and digital forms of money, including cryptocurrencies, stablecoins, and central bank digital currencies (CBDCs), differ from their predecessors in their inability to transform back into physical form.

Digital currencies are money that can be stored and transferred electronically. These functions of digital currencies can be centralized or distributed, and a central power, authority, or program supervises centralized digital currency transactions. At this point, the effects of the digital currency market on national economies and whether they may be replaced by national currencies are a major topic of discussion. Since there are no other currencies that have gained so much value in such a short time, interest in digital currencies is increasing.

CBDCs, which are seen as intangible and digital versions of fiat money, are money produced and used in electronic environments. As a direct legal payment tool, this money can be used as banknotes via electronic wallets for shopping and all kinds of payment transactions. Transactions are carried out in the digital environment under the supervision and control of monetary authorities. With these digital currencies, predominantly based on blockchain technology, electronic transactions can be made easier, faster, safer, and at a lower cost. Implementations for CBDCs may be based on blockchain or another type of distributed ledger technology (DLT), while others may only exist as centralized databases. There is no consensus on what the relevant technology means because blockchain technology has different and very wide application areas in terms of efficiency, trust in existing intermediaries, and governance. This technology enables the network of economic intermediaries to reach a consensus on the real status of some data held and shared jointly at regular intervals. The related shared data may exemplify the exchange of cryptocurrencies and other types of digital assets, thus making the technology applicable to multiple industries and public sectors (Catalini, 2018: 36-37).

## 2. RELATED WORKS

Although it has not been a very long time since the emergence of CBDCs, there is sizable literature (as mentioned below) regarding the related digital currency all over the world (Australia, China, Korea, Malaysia, Nigeria, Switzerland, Thailand, the United States of America, and the United Kingdom). Each of these studies has obtained several interesting, informative, and introductory data and has addressed CBDCs from different perspectives, such as blockchain applications, the impact of CBDCs on financial stability and credit supply, CBDC designs and projects carried out, central banks' approaches to CBDCs and determination of the factors affecting their decisions, difficulties encountered in the issuance of CBDCs, and the macroeconomic consequences they will cause.

Cunha et al. (2021) analyze the developments in the period, from cryptocurrencies to the emergence of CBDCs. They explain how the advantages and potential risks of CBDCs vary according to the characteristics of the intended scope of CBDCs (retail, wholesale, account-based, token-based) and at different implementation stages (launched, pilot, development, research, etc.). At this point, they emphasize that cryptocurrencies are effective in the adoption of CBDCs, but they differ from these currencies in many respects and should be designed uniquely. Terták and Kovács (2022), who mainly examine the digitalization process of money, also focus on why CBDCs should be introduced and what difficulties are encountered in this process. Separately, they mention the

precautions to be taken for the introduction of the projects of Digital Euro and Sweden's e-krona. Another study that evaluates what factors are effective in bringing CBDCs forward, their potential benefits, and the recent developments related to this issue was conducted by Ozili (2023). He concludes that CBDCs are effective in providing access to alternative paying solutions and transforming the financial system into a more accessible and inclusive system in the future.

CBDCs are also discussed in the related literature on how to determine optimal CBDC design. Agur et al. (2022) investigate the impact of cash, deposits, and financial intermediation functions on the optimal design of a CBDC (a cash-like CBDC or a noninterest-bearing CBDC). While noninterest-bearing CBDCs may have negative effects on loans and the level of output, a cash-like CBDC may reduce the level of cash. At this point, they argue that the most appropriate CBDC design should be as different as possible from existing payment instruments, especially in economies where the role of banks in financial markets is relatively lower. They also state that an optimal CBDC design may be possible if a balance is struck between the social value created by the diversity of payment instruments and the intermediation functions of banks. Tata (2023) also conducted a study on the design of CBDCs. He emphasizes that interval CBDCs have various uses in 4 areas: central banks' liquidity management, lending, monetary policy, and derivative transactions. He also argues that CBDCs can minimize the counterparty risk of some transactions, facilitate central banks' remuneration practices, and increase the diversity of monetary or financial instruments by adding time-specific features (such as limited-time CBDCs).

There have also been a few studies on the relationship between blockchain technology and CBDCs. Zhang and Huang (2022) evaluate the use of blockchain technology in CBDC design and note that permissioned blockchain is more suitable than permissionless blockchain. In addition, they conclude that no central bank has used blockchain-based CBDC thus far because of its performance, scalability, cross-chain interoperability, and usage scenarios. Similarly, Sethaput and Innet (2023) discuss the challenges encountered, technical solutions, and prospects for CBDCs, mainly blockchain or DLT applications to CBDCs, in light of the projects carried out by central banks.

In addition to all these studies discussed above, it is also possible to come across many other studies in the related literature that address CBDCs from different perspectives, such as financial stability, macroeconomic outcomes, monetary sovereignty, credit supply, security function, determinants of CBDC issuance, and Bitcoin and fintech sector reactions to CBDCs (Kumhof and Noone, 2021; Shen and Hou, 2021; Chapman, 2022; Chen and Siklos, 2022; Davoodalhosseini, 2022; Li et al., 2022; Barrdear and Kumhof, 2022; Horvath, 2022; Rojas-Breu, 2022; Williamson, 2022; Alfar et al., 2023; Kim and Kwon, 2023; Mzoughi et al., 2023; Rehman et al., 2023; Xia et al., 2023). In this context, many more studies may probably be conducted on such a dynamic subject that is still in the early stages of development.

Key questions around conceptualization use cases and monetary authorities' strategies for CBDCs are addressed in this paper, including the following: What do CBDCs stand for conceptually? What(s) do CBDCs have in common with or differ from cryptocurrencies? What steps have been taken toward CBDCs in both developed and developing countries that have initiated the practice? What kinds of strategies should be followed for CBDCs in light of current developments? In this context, the remainder of the study is organized as follows: Section 3 presents some theoretical information for digital currencies, mainly CBDCs. Section 4 evaluates the role of blockchain technology in CBDCs and the status of CBDCS by country at each income level. The final section consists of prospects and conclusions.

### **3. DIGITAL CURRENCIES**

Digital currencies have emerged in various forms, including CBDCs and private digital currencies (1st generation crypto assets such as Bitcoin, stablecoins such as Tether, and other special digital

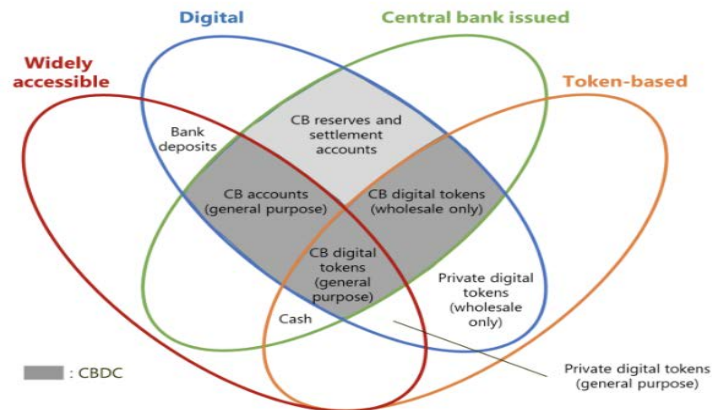
currencies). Following the initial introduction of Bitcoin in 2008, private companies issued more than five thousand cryptocurrencies, such as Ripple, Stellar, Tether, and Ethereum. This rise in cryptocurrencies poses a major threat to financial stability. It has brought with it many negative consequences, such as users incurring large losses, decreased confidence in these instruments, disruption of retail payment systems, and several economic impacts. The reputation of central banks, which are considered responsible for overseeing payment systems, has also been put at risk. Separately, they could not fulfill investment and payment functions effectively due to their decentralized structure, lack of wide acceptance, and insufficient regulatory supervision mechanisms. These undesirable developments have required monetary authorities to take various measures to prevent cryptocurrencies from becoming more interdependent with the financial system and economy (Carstens 2018: 8; Opore and Kim 2020: 110810).

Stablecoins, which emerged as a solution to reduce the volatility of cryptocurrency, are digital currencies that are linked to a single currency such as US dollars, euros, or exchange-traded commodities such as gold. They have a more stable outlook, as they are issued to be backed predominantly by central bank money, and their main responsibility is to accelerate the adoption of digital currencies. Since stablecoin transactions are conducted in a decentralized manner through distributed ledger technology, they are widely integrated with decentralized finance and designed to be the opposite of other cryptocurrencies, such as Bitcoin, which often see large-scale price fluctuations. Intended to be stable in terms of price, stablecoins can maintain almost the same value from the day a user buys them until the day they spend or trade them. This is because, unlike other cryptocurrencies, the price of most stablecoins is pegged to fiat currencies such as the US dollar or commodities such as gold. However, compared to CBDCs, although stablecoins offer significant opportunities in terms of direct automated provision of data and cost reduction for market participants, CBDCs can fulfill these functions more efficiently than stablecoins. As CBDCs have central bank backing, they are not subject to conflicts of interest around asset backing and stabilization mechanisms. Moreover, their value can be pegged to the reference currency, thus eliminating fluctuations in value (Mancini-Griffoli et al. 2018; Arner et al. 2020; Allen et al. 2022; Gadzinski et al. 2023; Lyons and Viswanath-Natraj 2023).

### **3.1 Central Bank Digital Currencies**

Central banks have begun to work on alternative instruments, and the CBDCs have come to the fore due to the instability concerns that cryptocurrencies and stablecoins may cause to compete with traditional payment systems. Built on a new technological layer inspired by the advances offered by blockchain, CBDCs are a digital version of government-backed fiat money. This type of digital currency, accelerated after the emergence of stablecoins, is issued by a central bank. Cryptocurrencies and CBDCs have similar features, such as being used in electronic payments, digital wallets playing an active role in their storage, and transfer transactions taking place through blockchain technology without the need for any third party. At this point, CBDCs are constantly associated with cryptocurrencies as a technological infrastructure, but they are sharply differentiated from cryptocurrencies by representing a claim on a central bank and its central issuance feature. Having the central banks behind them and the determination of monetary policies in this direction ensure that CBDCs have intrinsic value. On the other hand, cryptocurrencies have a completely decentralized structure and are not controlled by any person or entity. Although CBDCs are based on blockchain technology, such as cryptocurrencies, only selected individuals and institutions can access these networks. In addition, while cryptocurrencies generally do not have a monetary equivalent, CBDCs have asset equivalents. (IMF 2020: 9; Boar and Wehrli 2021: 4; Zhang and Huang 2022: 264). The main characteristics of CBDCs are clearly illustrated in the Money Flower Venn diagram put forward by Bech and Garratt (2017):

**Figure 1: The Main Characteristics of CBDCs**

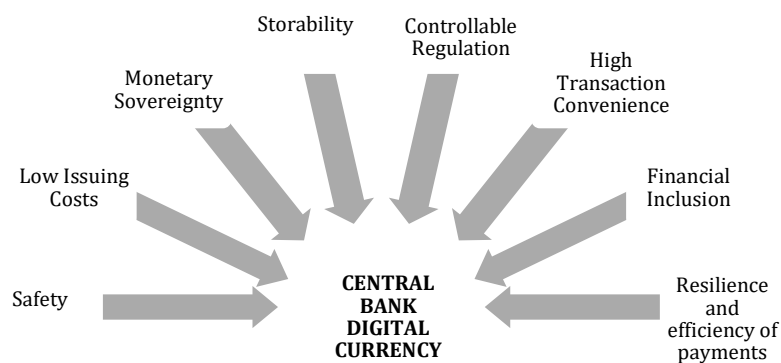


**Source:** Bech and Garratt, 2017.

According to the money flow taxonomy presented in Figure 1, CBDCs have four main characteristics: issuer (central bank); form (digital or physical); accessibility (broad or restricted); and transfer mechanism (centralized or decentralized). The remaining gray areas in the diagram include the two main types of CBDC. Basically, retail-wholesale is available to the public, but there is a limited-access digital facility for wholesale payments (e.g., interbank payments or securities settlement). In addition, retail CBDCs can be account-based or token-based (Bech and Garratt 2017: 59-60).

Central banks around the world have taken a positive attitude toward CBDCs to protect their local currencies against competition based on digital superiority. Positive contributions such as increasing transaction efficiency, preventing falling behind the digitalized economy, and eliminating the digitalized dollar dominance by enabling faster, cheaper international trade and financial transactions have been very effective in the emergence of this attitude (Huang and Mayer 2022: 11). In addition to these contributions, it is possible to consider many other functions of CBDCs (Han et al. 2019: 265; Soderberg 2022: 4-7; Zang and Huang 2022: 264):

**Figure 2: The Functions of CBDCs**



**Source:** Created by author, based on (Soderberg 2022: 4-7; Zang and Huang 2022: 264).

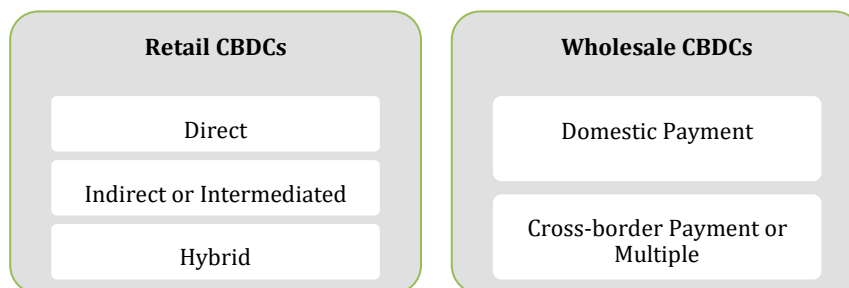
As can be seen from Figure 2, there are several areas in which CBDCs are expected to exert influence and facilitate. First, CBDCs are considered as reliable as cash, with electronic advantages and possible high demand levels (Bank for International Settlements, 2021: 4). If some security risks arise from the design and operational use of CBDCs, central banks could manage these risk factors by imposing restrictions on limit balances and transfer transactions, providing controls on liability rules, and introducing security protocols. Moreover, the central bank guarantee of digital

money as a legal tender increases public confidence in the security of the system and supports its acceptance and widespread use. Public confidence is strengthened by the fact that CBDC is central bank money and does not pose a credit risk to the holder (Perret, 2019; Kahn and Rivadeneyra, 2020: 1). Second, CBDCs have the potential to have a positive impact on financial inclusion by digitizing the value chains in the economy, providing access to digital financial services without the internet, and increasing the efficiency of digital payments. In addition, the fact that CBDC is a simplified digital currency system that is fully interoperable with other systems means that an individual's digital currency no longer needs to be tied to a single mobile operator. This increased financial access gives customers confidence that this tool can be used regardless of their banking or partner relationships. Additionally, they may keep costs low and reduce transaction costs by a minimal fee (Bank for International Settlements, 2022: 13; Ozili, 2022: 243).

### 3.1.1 The Main Types of CBDCs

There are two types of CBDCs, wholesale (for financial institutions) and retail (for household and nonfinancial businesses only), in terms of access to digital currencies. Wholesale CBDCs, similar to central bank deposits and used to increase speed, flexibility, and efficiency in interbank settlement risks and cross-border payments, are only available to financial institutions. On the other hand, retail CBDCs, considered a form of digital cash, can be accessed by all economic units, such as individuals, businesses, government institutions, and financial institutions, and used to perform transfer and payment transactions with cooperation between the central banks and monetary authorities of countries (Jahan et al., 2022: 5-6). As shown in Figure 3, these two types of CBDCs are also divided into groups in terms of whether banks and other financial institutions will be included in the system and, if so, at what level:

**Figure 3:** Subgroups of CBDCs



**Source:** Created by author, based on (Geroni 2021a).

In direct retail CBDCs, where all payment transactions take place through the central bank, retail transactions by individuals or businesses are recorded through special accounts at the central bank, so there are no financial intermediaries in the system. At this point, central banks need to have a strong technical infrastructure to overcome the transaction intensity. Additionally, this type of CBDC does not benefit from the speed, resilience, and efficiency that financial intermediaries, who are in closer contact with customers, can provide to the system. For instance, financial intermediaries may help maintain the flow of payments by taking risks during a connection outage or offline payment. However, there is no such guidance in the direct retail CBDC; therefore, customer satisfaction decreases because of not communicating with the customer at the required level. In another type of retail, indirect CBDC, the central bank conducts retail money issuance indirectly through intermediaries. The intermediaries communicate with retail customers and send payment messages to other intermediaries and wholesale payment messages to the central bank. Therefore, they fulfill all the responsibilities of the regulatory authority for retail money customers on the money they issue. The central bank's responsibilities are more limited, and it only holds wholesale account information. Since the central bank does not keep evidence of individual

accounts, it cannot fulfill the claims of consumers without records from intermediaries, and if the intermediaries become insolvent, the process of identifying statutory beneficiaries can be cumbersome and lengthy. Hybrid retail CBDCs are the model between the direct retail and indirect wholesale CBDC models, hence the two-tier structure. The central bank keeps a copy of all retail balances but does not interact directly with retail users, focusing on a limited set of core processes, while intermediaries perform other services, including instant payment confirmation. This allows for portability between intermediaries and transfers from one payment service provider to another in case of failure. As customers' balances are segregated from the payment institutions' accounts, in the event of the insolvency of the payment institution, consumers' assets are not affected (BIS Annual Economic Report 2021: 78; Deloitte 2022; Turkey Informatics Foundation 2022: 11-12).

Wholesale and systemically important transactions, on the other hand, can usually be routed through the central banks responsible for making these payments. At this point, wholesale CBDCs, developed for use by financial institutions, make it possible to transfer funds and settle transactions faster, more reliably, and at a lower cost. Using CBDCs in this way increases efficiency in both domestic and cross-border payments. While wholesale CBDCs are located and traded in the same economic environment as retail CBDCs, they differ in some respects from the type of CBDC available to individuals. For instance, the use of retail CBDCs is suitable for central banks in developing countries, while this is true for central banks in developed countries in wholesale CBDCs. Second, the main objective of retail and wholesale CBDCs is to conduct daily transactions for households and businesses and to exchange and trade among central banks and private banks. Finally, in retail CBDCs, the responsibility is to prevent interference by intermediaries and illegal transactions, while wholesale CBDCs are responsible for making wholesale transactions more reliable, faster, and at a lower cost (Geroni 2021a).

In practice, it is possible to encounter various pilot studies conducted for retail CBDCs such as E-krona (Sweden), E-Peso (Uruguay), E-Hryvnia (Ukraine), Project Sand Dollar (The Bahamas) and The Digital Eastern Caribbean Dollar (Eastern Caribbean Central Bank). Similarly, several pilot studies have also been launched for the wholesale CBDC type among the central banks and monetary authorities of the countries. Project Stella (European Central Bank and Bank of Japan), Project Ubin/Jasper (Monetary Authority of Singapore and Bank of Japan and Canada), Project Inthanon/LionRock (The Hong Kong Monetary Authority and Bank of Thailand), and Project Dunbar (Reserve Bank of Australia, Central Bank of Malaysia, Monetary Authority of Singapore, and South African Reserve Bank) may be shown as the leading examples of wholesale CBDCs (KPMG 2020; BIS Innovation Hub 2022; Sethaput and Innet 2023). The details of the status of some CBDC cross-border projects is shown in Table 1:

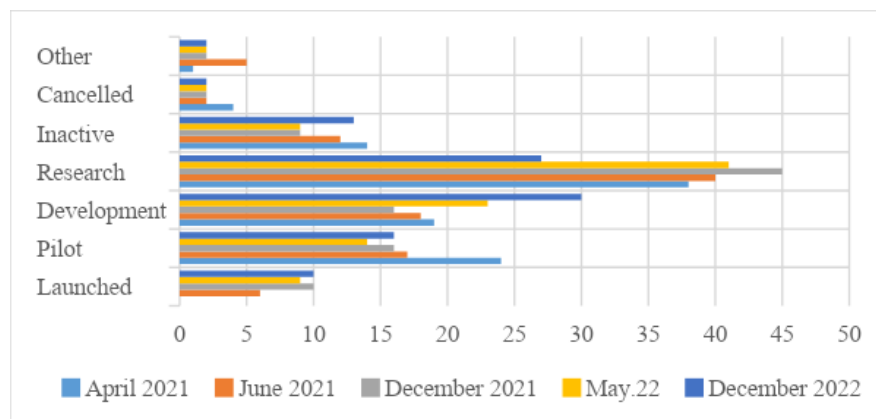
**Table 1:** CBDC Cross Border Projects for Some Countries Worldwide

Project	Period	Countries	Use Case
Project Jasper	2017	Canada, UK and Singapore	Wholesale
Project Aber	2019	Saudi Arabia and the UAE	Wholesale
Project Aurum	March 2021	Hong Kong and BIS	Retail and Wholesale
Onyx/Multiple wCBDC	July 2021	France and Singapore	Wholesale
Multiple CBDC Bridge	September 2021	Thailand, China, Hong Kong and, the UAE	Wholesale
Project Helvetia	January 2022	Switzerland and, the BIS	Wholesale
Project Dunbar	March 2022	Australia, Singapore, Malaysia and, South Africa	Wholesale
Project Rosalind	June 2022	United Kingdom and, the BIS	Retail
Project Sela	June 2022	Israel, Hong Kong and, the BIS	Retail
Project Icebreaker	September 2022	Israel, Norway, Sweden and, the BIS	Retail
Project Mariana	November 2022	France, Switzerland, Singapore and, the BIS	Wholesale

**Source:** Created by author, based on <https://www.atlanticcouncil.org/cbdctracker/>.

Considering the projects specified in Table 1, it is possible to say that increasing the efficiency of money transfers and foreign exchange transactions and reducing costs are in the lead. Thereafter, to explore the feasibility of issuing CBDCs, to allow international settlements across multiple CBDCs, to facilitate exchange between different currencies, and to explore the CBDCs' cybersecurity implications, among other purposes, each project endeavors to complete its objectives within the stipulated deadlines. For example, the results from the Icebreaker project, which was recently announced as completed on March 6, 2023, have shown that CBDC payments may be a cheap and reliable alternative to cross-border payments. Although there are many wholesale CBDC pilot projects, especially in the Far East, these projects are considered an intermediate stage before the transition of these countries to retail CBDC. Many countries are also working on projects related to retail CBDC (BIS Innovation Hub, 2023).

**Figure 4:** CBDC progress between April 2021 and December 2022



**Source:** Created by author, based on <https://www.atlanticcouncil.org/cbdctracker/>.

According to Atlantic Council research results summarized in Figure 4, the number of countries that attempted to develop a CBDC project between April 2021 and December 2022 increased from 74 to



114, an increase of approximately 35%. Especially in April 2021-December 2022, numerous projects have been launched by cooperating between various countries (Switzerland, Australia, Singapore, the United Kingdom, Malaysia, South Africa, Israel, Norway, Sweden, Switzerland, and Hong Kong) and the BIS as a monetary authority.

### **3.1.2 The Design of CBDCs: Account-based and Token-based CBDCs**

According to their configuration rules, CBDCs are categorized into two groups: account-based and token-based. In account-based CBDCs, people participating in the system have an account with their identity, and the end user is assigned an account by the central bank or intermediary institutions. They are effective in reducing transaction costs under the control of central banks. On the other hand, by eliminating the anonymity of blockchain technology, account-based CBDCs increase the risk of disintermediation by established financial institutions, as they require central banks to create accounts on behalf of all users and ensure their follow-up. Token-based CBDCs use distributed ledger systems such as Bitcoin or Ethereum. In token-based CBDCs, digital coins are transferred between user wallets, and the change in ownership of these CBDCs is recorded on the blockchain. In this context, blockchain-based systems are required to use a token that represents a digital form of fiat currency. On the other hand, token-based CBDCs bring about more profound changes than account-based CBDCs, as they create a new space for central banks. While account-based CBDCs have similar dynamics to account-based central bank money, token-based CBDCs require a reorganization of financial regulations, especially the definition of central banks' duties and powers. Any lack of regulation at this point is likely to have a negative impact on the effective functioning of CBDCs and thus the financial system. At this point, central banks need to choose between token-based or account-based CBDCs to ensure the anonymity of users by considering these amendments (Nolting et al., 2020; Bilotta and Botti, 2021; Lee et al., 2021; Priyadarshini and Ka, 2021).

## **4. BLOCKCHAIN-BASED CBDCs: WHAT IS THE ROLE OF BLOCKCHAIN IN CBDCs?**

Blockchain technology is a decentralized and distributed digital ledger that uses cryptological techniques and peer-to-peer communication to record and verify the authenticity of transactions. First mentioned theoretically in 2008, this technology was later put into practice with the launch of the Bitcoin currency (Nakamoto, 2008). Developments around the world bring with them several transactions and a new way of thinking. In this context, blockchain is one of the products of this new way of thinking that will have the most revolutionary results, and to understand and apply this technology, experience must be gained. As with any new technology, the experimental processes that start with concepts in blockchain need to be transformed into pilot phases, and these into final products. The main feature that distinguishes blockchain from other technologies is the need to "work together" in environments such as intersectoral consortiums and platforms. While blockchain, as a new thinking pattern, increases the importance of ecosystems, it also increases the need for companies and their products to be able to create value while bringing ecosystems to the forefront (Turkey Informatics Foundation, 2022).

Developments in cryptocurrencies and blockchain technology have been highly influential in the shift toward digital currencies, mobile payments, etc. For instance, Cambodia has leveraged similar technologies, such as blockchain and DLTs, to boost mobile payments (International Monetary Fund 2022). Blockchain technology, with its features such as auditability and immutability, largely meets the CBDC criteria and allows CBDCs to be issued in a way that can reduce costs and increase payment efficiency. At this point, there is an expectation that digital financial instruments will drive the increasing use of blockchain technology. In other words, CBDCs will be the driving force behind encouraging more people to use blockchain. The fact that financial and real-world assets are traded in tokens, especially the adoption of CBDCs by major central banks, raises strong expectations that

blockchain technology will be used by billions of users and will have a transaction capacity measured in trillions of dollars. According to a Citi GPS report, by 2030, up to \$5 trillion worth of CBDCs could be in circulation in major central banks, and half of the world's economies could be linked to distributed ledger technology. However, there is not yet a consensus on whether central banks should issue digital currency through distributed ledger technology or the traditional centralized system. The potential for digitization through blockchain has been highly transformative, especially over the last few years, but mass adoption is still lacking (Citi GPS, 2023).

#### **4.1 Benefits and Challenges of Blockchain-based CBDCs**

Blockchain technology is inherently decentralized. The decentralization of blockchain technology makes it independent from a central authority and resistant to tampering and censorship. One of the most important benefits of blockchain technology is that it facilitates secure and transparent transaction processes. Since blockchain technology is decentralized and handles transactions transparently, it allows verification of processes without the need for intermediaries, reduces the risk of fraud and abuse, and increases efficiency. Overall, blockchain technology provides a secure and transparent solution for recording data and transactions (Nakamoto, 2008).

Blockchain-based CBDCs provide several benefits in terms of increasing trust in the system, supporting programmability, innovation, and data usability with the features of having a distributed database, transparency of all records recorded in the system, the inability to make retroactive transactions related to the data recorded in the ledger, and reducing the need for third parties. For instance, with a blockchain-based CBDC, central banks may both control their local currencies and enforce the principles of confidentiality and independence in the use of CBDCs by end users. It is important that users do not need to rely on third parties in the context of this trust element. The fact that the transactions that make up the blocks in the blockchain system, whose integrity can be trusted, can be queried is another factor that increases the reliability of this database (Bouchaud et al., 2020; Geroni, 2021b; Zhang, 2022).

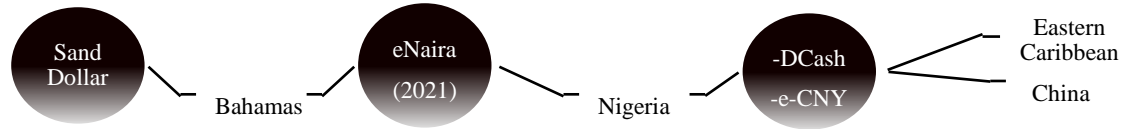
However, central banks have important duties for blockchain-based CBDCs to function effectively in practice. In this context, they should be able to develop a system that supports several capabilities, such as the ability to make payments between individuals at any point of sale or online or to trade CBDCs with commercial bank money or cash. If a blockchain-based technology is chosen for the use of CBDC, it is extremely important to perform these transactions with the features of resilience, robustness, continuity, security, and privacy. Otherwise, blockchain-based CBDCs are likely to have some disadvantages (Sethaput and Innet, 2023; Syed, 2023). There are many CBDC design models with their own level of privacy and security. For instance, in a permissioned blockchain, a very small number of users can see and verify transactions. The identities of the participants, as well as all the transactions that take place, can be monitored by permissioned participants but are completely hidden from the public. At this point, the asset nodes are of great importance, as in the event of an attack, all data can be leaked, posing a security risk. In a public blockchain such as Bitcoin and Ethereum, security threats such as this are less likely to occur. If not, all transactions are encrypted on the public blockchain, an environment of trust with no intermediary is relatively secure against possible cyber-attacks. On the other hand, since transactions are open to everyone participating in the blockchain, the level of privacy is lower, and real users can be easily identified (Lee et al., 2021: 17).

#### **4.2 Current Status and Future Prospects of CBDCs**

The Bahamas was the first country in the world to have a CBDC, and the digital version of the Bahamian dollar is called the 'sand dollar' (launched on October 20, 2020), thus eliminating the difficulties of reaching cash with ATMs spread over 700 islands in the country. In 2021, Nigeria

issued eNaira, and subsequently, the most ambitious project on CBDC was put forward by the Chinese central bank as a pilot application, as shown in Figure 5:

**Figure 5: First Examples of CBDCs**



**Source:** Created by author, based on (Kosse and Mattei, 2022: 1).

If the Chinese experience yields good results, digitization, innovation, and financial inclusion may increase in one of the world's largest and most vibrant economies, and this success could force other countries to do the same (Adrian and Mancini-Griffoli, 2021; Boar and Wehrli, 2021: 3). Such developments around the world regarding CBDC projects have gained momentum in recent years. As stated in the sections below, it is possible to conclude that the research projects initiated to explore the potential of CBDCs are quite high and serve many purposes. However, it should be noted at this point that CBDC issuance is likely to have different consequences for developed and developing countries. Due to their functions, CBDCs are expected to have a negative impact on international capital flows and exchange rates, especially in emerging market economies, making them difficult to control. Moreover, the systemic impact of the monetary policies of advanced economies towards CBDCs is likely to increase the exposure of emerging market economies and lead to a loss of financial independence. On the other hand, CBDCs are also likely to have positive repercussions on the overall level of credit and banks' disintermediation risks, especially in emerging market economies (Acar Balaylar, 2023; Tan, 2023). Therefore, this study examines the developments and steps taken on CBDCs around the world according to the income level of countries<sup>2</sup>.

#### 4.2.1 High-Income Level Countries

Considering the status of CBDCs, it can be inferred that many countries have taken several initiatives regarding CBDCs, which are the digital versions of the official currencies of the countries and aim to minimize dependency on other countries. The most recent developments (2017-2023) in CBDCs in some high-income countries are shown in Table 2.

**Table 2: High-Income Level Countries' CBDC Initiatives**

Digital Currency	The Stage of CBDC Adoption	Types of CBDC	Central Bank
e-shekel	Proof of concept	Retail	Bank of Israel
e-HKD	Proof of concept	Retail	Hong Kong Monetary Authority
Hungary CBDC	Proof of concept	Retail	Central Bank of Hungary
Digital Yen	Proof of concept	Retail	Bank of Japan
e-krona	Proof of concept	Retail	Sveriges Riksbank
E Dollar	Research	Retail, Wholesale	Bank of Canada
Helvetia	Research	Wholesale	Swiss National Bank
eAUD	Research	Wholesale	Reserve Bank of Australia
Qatar CBDC	Research	Retail	Qatar Central Bank
Denmark CBDC	Research	Wholesale	Nationalbanken

**Source:** Created by author, based on <https://cbdctracker.org/>.

<sup>2</sup>The countries have been categorized according to their income levels based on World Bank data (<https://data.worldbank.org/country>).

As can be seen from Table 2, there are many countries at different stages of implementation in the development of CBDCs. While some countries, such as Israel, Hong Kong, Hungary, Japan, and Sweden, have progressed to the proof of concept (POC) stage, Canada, Switzerland, Australia, Canada, Qatar and Denmark continue to research. The steps taken by these countries towards CBDCs are given in detail in the sub-headings below.

#### **4.2.1.1 High-Income Level Countries Published a CBDC Proof of Concept**

The Bank of Israel formed a team in 2017 to identify the potential benefits and harms of CBDC issuance. In 2018, the team concluded that it would not be appropriate to issue a digital currency in the near future. However, it has been stated that studies will continue to be prepared if the conditions are appropriate and that developments such as the level of cash usage, the adoption of electronic payments, technological developments, the availability of stablecoins, and the level of competition in the payment system will be closely monitored (<https://cbdctracker.org/currency/israel-e-shekel>).

Hong Kong's initiatives for CBDCs first started with Project LionRock in 2017 and continued with Project Inthanon-LionRock in 2019 to evaluate the function of CBDCs in cross-border payments. The related project entered the second phase in 2020 and was renamed the Multiple CBDC Bridge project in 2021 with the inclusion of the Central Bank of the United Arab Emirates and the Digital Currency Institute of the People's Bank of China (Hong Kong Monetary Authority 2022).

In the case of Hungary, the MNB conducted its first retail CBDC pilot project in September 2020 to support the digital financial inclusion of students aged 8-14 and to identify a potential operational model for the CBDC system in the future. The target group considered in the pilot project is seen as an opportunity to increase the financial awareness of young people who do not currently have a relationship with the bank but are expected to have potential income and spending levels in the future. To achieve successful results from the initiated project and to design an appropriate CBDC, a seven-step decision-making process was determined. At this point, it is not currently considered necessary for the Central Bank of Hungary to implement a CBDC project in the very short term, but it is considered necessary to be prepared in case of economic or political need (Fáykiss et al., 2022).

Similarly, the Bank of Japan conducted a "Proof of Concept (PoC) Phase 1" between April 2021 and March 2022, examining various design alternatives to see if the core functions could be performed as they should be. PoC Phase 2 was then conducted over the period April 2022-March 2023 and focused on the potential use of new technologies and databases not covered in Phase 1. It also experimented with measures to stabilize the financial system and improve the ease of payment and ledger design. The PoCs confirmed success in achieving the desired results and the transition to the planned CBDC pilot project but noted that the final decision on CBDC issuance has not yet been made, at which point a CBDC Forum will be created to solicit input from private businesses (Bank of Japan, Payment and Settlement Systems Department, 2023).

Sweden, one of the countries with one of the lowest levels of cash use in the world, could carry out their investigations on CBDCs with relative ease. Sveriges Riksbank conducted a digital currency pilot between February 2020 and February 2021 for the development of the E-krona. The test network for this pilot was built on a DLT and token-based platform called Corda. However, no decision has yet been made on whether an e-krona will be issued, how it will function, or on which technology it will be based (Sveriges Riksbank, 2023; <https://cbdctracker.org/currency/sweden-e-krona>).

#### **4.2.1.2 High-Income Level Countries Completed the Research Phase**

The Bank of Canada first launched Project Jasper in 2017, with an emphasis on digitization in the payments system. This project, which has a multilateral partnership structure including Payments Canada, financial innovation firm R3 Lab and Research Centre, CIBC, TD, Scotiabank, Bank of

Montreal, RBC, National Bank, and HSBC, is the first project in which a central bank cooperates with the private sector in terms of researching DLT applications. Looking at recent times, according to the press release made on May 8, 2023, the Bank of Canada has entered a new phase of testing the viability of CBDCs for the CBDC, initiating the consultation process for the digital Canadian dollar. The digital dollar is seen as an official, secure, and stable payment option, but it is stated that there is no need for the digital Canadian dollar now. In addition, it is emphasized that if the digital dollar is issued, the use of banknotes will continue (Payments Canada, Bank of Canada and R3 2017; Bank of Canada, Media Relations, 2023).

Considering Switzerland's CBDC efforts, it was seen that Switzerland was involved in two projects: Project Helvetia (2020) and Project Jura (2021). In Phase I of Project Helvetia, published in partnership with the BIS Innovation Center (BISIH), Swiss Center, SIX Group (SIX), and the Swiss National Bank (SNB), two approaches to settling tokenized assets with central bank money were tested. The results showed that wholesale central bank digital currency (wCBDC) can be effectively used in tokenized asset platforms and that the functionality of tokenized assets is greater than traditional reserve balances. Phase II of the project assessed the legal and policy implications of issuing wCBDC. The Jura Project, a continuation of the Helvetia project involving Switzerland, investigated the cross-border settlement of tokenized assets and foreign exchange transactions in euro and Swiss franc wCBDCs (Bank for International Settlements, SIX Group, and Swiss National Bank, 2022).

In 2022, the Reserve Bank of Australia (RBA) participated in a research project with the Digital Finance Cooperative Research Centre (DFCRC) to examine the design, potential use, technological requirements, and legal and regulatory aspects of eAUD, a general-purpose pilot CBDC. The relevant pilot project report is planned to be published in mid-2023, and it is stated that the findings will be decisive for the RBA's attitudes toward CBDCs (Reserve Bank of Australia and DFCRC, 2022). Finally, Denmark and Qatar are also still exploring whether to issue their own digital currencies.

#### 4.2.2 Middle-Income Level Countries

While many advanced economies have high levels of bank account ownership, a large share of the population in emerging markets and developing economies has low levels of account ownership. Therefore, CBDC issuance in emerging markets and developing economies is likely to bankize large unbanked populations and increase financial inclusion. This is expected to have a positive impact on the overall credit level and reduce the risk of bank disintermediation (Tan, 2023). At this point, it is observed that middle-income countries have also taken important steps towards CBDCs to benefit from these advantages and to design a CBDC that is suitable for their own country's conditions. Table 3 shows that the central banks of some middle-income countries have taken important steps toward CBDCs:

**Table 3:** Middle-Income Level Countries' CBDC Initiatives

Digital Currency	The Stage of CBDC Adoption	Types of CBDC	Central Bank
Digital Lira	Proof of concept	Retail	Central Bank of the Republic of Turkey
Digital Lari	Proof of concept	Retail	National Bank of Georgia
Digital Ruble	Proof of concept	Retail	Bank of Russia
Mauritius CBDC	Research	Retail	The Bank of Mauritius
Nepal CBDC	Research	Retail	The Nepal Rastra Bank
Tanzania CBDC	Research	Retail, Wholesale	Bank of Tanzania
Mexico CBDC	Research	Retail	Banco de México
Jam-Dex	Launched	Retail	Bank of Jamaica
e-Naira	Launched	Retail	Central Bank of Nigeria

**Source:** Created by author, based on (<https://cbdctracker.org/>).

As can be seen from Table 3, Mauritius, Nepal, Tanzania, and Mexico proceed with comprehensive research on the optimal design of CBDCs, while Turkey, Georgia, and Russia are at the proof-of-concept stage. In addition to these countries, Jamaica and Nigeria have already launched CBDC projects. The actions taken for CBDCs in these countries, which are at different stages, are discussed under the following sub-headings:

#### **4.2.2.1 Middle-Income Level Countries Published a CBDC Proof of Concept**

The Central Bank of the Republic of Turkey (CBRT) has initiated a research and development project to explore the potential benefits of introducing the Digital Turkish Lira to complement the existing payment infrastructure. The project has now moved to the next stage with the participation of technology stakeholders after the completion of the proof-of-concept stage. The technological research, development, and testing processes of the project will be carried out in close cooperation with technology stakeholders. As part of this project, the CBRT and ASELSAN signed bilateral memorandums of understanding with HAVELSAN and TUBITAK-BILGEM to create a "Digital Turkish Lira Cooperation Platform". The platform is intended to facilitate the establishment of a digital currency and will be used to conduct technological research, development, and testing processes in close cooperation with technology stakeholders. It is also expected to be expanded with new participation in light of relevant pre-application tests. The economic, legal, and financial requirements of the Digital Turkish Lira will be determined after the capacity measurements of different technological alternatives are completed. The architectural setup will also need to be finalized before this determination can be made. Once these two steps are completed, it will be possible to determine whether the existing technologies can meet the requirements of this currency (CBRT, 2021). Continuing tests on unique architectural constructs designed to address issues such as the use of distributed ledger technologies in payment ecosystems and integration with instant payment systems reveal that digital identification is critical for the legal dimension of the Digital Turkish Lira project. Therefore, the CBRT will prioritize research on the economic and legal framework of the Digital Turkish Lira, as well as its technological requirements (CBRT, 2022). In addition, a decision regarding the infrastructure on which the CBDC design will be based has been taken in the Eleventh Development Plan of Turkey 2019-2023. Accordingly, Decision No. 249.5 of this development plan states, "a blockchain-based digital central bank currency will be put into practice" (Presidency of the Republic of Turkey, Presidency of Strategy and Budget, 2020).

The Central Bank of Georgia (NBG) has been working on CBDCs since early 2020 and has a very positive attitude toward digital currency. There is an expectation that it will have a positive impact on various areas, such as the level of financial access, efficiency of intermediation services, effectiveness of monetary policies, and diversity of innovative products and services. Over approximately two years, NBG has carried out a comprehensive assessment of the relevant financial technology in cooperation with many technology companies, both technologically, politically, and legally. Finally, NBG published a report named 'Project DGEL' in January 2023 and announced that they will conduct CBDC initiatives with the Technology Partner for the DGEL pilot project, which is an important step for CBDCs (National Bank of Georgia, 2023). The comprehensive work of the Central Bank of Georgia on CBDCs was appreciated by Central Banking and received the "CBDC Initiative" award at the sixth annual FinTech RegTech Global Awards (Popowicz, 2023).

In 2020, the Bank of Russia prepared a detailed consultation paper on whether CBDC issuance is necessary, and if so, why, what factors might increase the need for CBDCs, and what factors should be considered in CBDC design (Bank of Russia, 2020). The Digital Ruble Concept was published in April 2021; the Digital Ruble platform was piloted in a test environment in 2022; and the pilot phase with real money was planned for April 2023. On July 11, 2023, it was reported that the law on the issuance of the digital ruble, planned to be used primarily as a means of money transfer and

payment in Russia, was adopted. It was announced that the main provisions of the law on the implementation of CBDC, under which it will not be possible to open deposits or obtain loans in digital rubles, will enter into force on August 1, 2023 (Grishchenko et al., 2023; Bank of Russia, 2023).

#### **4.2.2.2 Middle-Income Level Countries in the Research Phase**

As of the project launched in 2020, the Bank of Mauritius has adopted a cautious approach in its research on the benefits and design of Mauritius CBDC, dubbed the Digital Rupee. In this context, the Bank plans to launch a pilot project, and the Digital Rupee is expected to be launched in November 2023 after finalizing the design specifications (Bank of Mauritius Public Notice 2023). The Bank of Mauritius, which is the first central bank to receive technical assistance from the International Monetary Fund (IMF) to optimize the design conditions of the Digital Rupee, has stated that the value of the Digital Rupee will be the same as physical banknotes and coins and will be differentiated from crypto assets in this respect (Bank of Mauritius Public Consultation Paper, 2023).

In line with the efforts of many countries to adopt digital currency, Nepal Rastra Bank (NRB) has also included a work plan for CBDCs in its annual plan for FY 2021/22 and has constituted a CBDC steering committee to revise the Nepal Rastra Bank Act and take necessary steps to enable the issuance of digital versions of Nepali currency (Nepal Rastra Bank, 2022). Similarly, Tanzania, an East African country, announced on January 14, 2023, the establishment of a multidisciplinary technical team to identify the potential risks and advantages of CBDCs. The team, formed by the Central Bank of Tanzania, is scheduled to conduct research on CBDC forms, issuance patterns, design features, and other issues. The bank has also stated that it will be informed again on what steps can be taken for CBDC issuance after the completion of the research phase (Bank of Tanzania, 2023). The Central Bank of Mexico, Banco de México, also expressed its positive view on CBDCs on December 29, 2021, stating that the pilot will continue until 2025 and that CBDC issuance is planned for 2025. There was a consensus that Mexico's CBDC should focus in particular on issues such as confidentiality, transferability, and security (authentication). In addition, the statement issued by the Banco de Mexico indicated that the CBDC would not be designed as an interest-bearing instrument but rather as an instrument for payments (Abogados, 2022).

#### **4.2.2.3 Middle-Income Level Countries Launched a CBDC Project**

The Jamaican government has a positive attitude toward the use of CBDCs and has recently introduced two incentive programs, the 'Small/Micro Merchant Incentive Program' and the 'Wallet-holder Individual Loyalty Program', to encourage the use of CBDCs by both businesses and individuals and support financial inclusion (Ledger Insights 2023). JAM-DEX which is a legal tender, can be exchanged for physical cash in exchange for dollars and can be used by both individuals and businesses to make payments or preserve value. On August 9, 2023, the Bank of Jamaica announced that a total of J\$230 million in CBDCs had been issued for the first time to deposit-taking and payment service institutions for the CBDC pilot, which will be completed in December (Bank of Jamaica, 2021). As the first African country to issue CBDCs, Nigeria has also shown a trend toward CBDCs with various expectations, such as acceleration of cross-border trading transactions, increased level of financial participation, cheaper and faster remittance entries, and increased efficiency of monetary policies, payment systems, and tax practices. The easy adaptation of Nigerian citizens to CBDCs, the high number of central banks taking initiatives against CBDCs, the emerging cybersecurity threats in payment transactions, and the drive to take control have triggered the Central Bank of Nigeria to launch a pilot project called Project Giant in mid-2021 (Ozili, 2023). e-Naira, the second CBDC issued after the Bahamas Sand Dollar, was premiered in October 2021, but the adoption level of e-Naira is not yet at the desired levels, according to an IMF report published in 2023 (Ree, 2023).

## 5. DISCUSSION AND CONCLUSION

Many central banks around the world have accelerated their efforts to minimize the potential risks that the digitalization process may pose to traditional payment systems and to stay ahead of current developments. The report published on March 13, 2023, by Juniper Research, which operates in the FinTech, and payments markets, includes the expectation that significant progress will be made in the future for CBDCs. According to the related report, the value of payments made through CBDCs in 2023 is only 100 million dollars, and this value is expected to reach 213 billion dollars annually by 2030. The current situation shows that it is highly likely that the number of studies conducted to research and test CBDCs will increase and that the use of CBDCs will become widespread in this context. The widespread use of CBDCs prevents the central banks of countries from being indifferent to the relevant digital currency and determines their attitude toward CBDCs. However, it should be noted here that each country's CBDC has different characteristics, serves different purposes, and is shaped according to the conditions of the country. Therefore, a single CBDC design is not possible, and central banks should design CBDCs with the most appropriate structure for their countries to eliminate the potential risks that they may pose. In this context, countries in various income groups try to have as much information as possible about the transition to CBDCs and the post-transition process and to follow current developments closely. For instance, as seen from the IMF (2023) report, more than 40 countries have requested IMF assistance in CBDC capacity building, and the IMF has developed various recommendations. In addition, the IMF has announced that a CBDC handbook will be developed to concretize and compile the results of its work on CBDCs. It is expected that this handbook may be an important source of reference for policymakers, especially in developing countries, and that it will make an important contribution to countries in determining whether they have a suitable structure for them.

As is known, CBDCs are expected to provide benefits in many areas, such as encouraging financial inclusion, reducing transaction costs, increasing the efficiency of payment systems and the stability of monetary and fiscal policies, and preventing informality. On the other hand, decentralization, money laundering, a lack of confidentiality, and infrastructure are among the major risks that CBDCs may pose. In this respect, first of all, the rule-making and enforcement functions of regulatory and supervisory agencies should be enhanced in order for the central banks of the countries to benefit from these advantages to the maximum extent, to rule out potential risks, and to establish a sound CBDC system. Therefore, the central bank of each country willing to issue CBDCs should cooperate with these institutions and adopt a conscious attitude to prevent possible money laundering, etc., attempts. In addition, countries should meticulously analyze their sociodemographic structures in detail and accurately identify the needs of potential parties that may have difficulties adapting to the CBDC system. Only then will it be possible to expand financial inclusion, one of the key benefits of CBDCs. It is also crucial for CBDCs, which are seen as a new financial oversight tool, that countries create their own technical infrastructure systems with a focus on preventing cyber-attacks.

This study may contribute to a better understanding of a digital currency with such high development potential by both official authorities and individuals as potential users and to increase awareness of this issue. In future studies to be conducted on this subject, it would be beneficial to consider countries on an individual basis and to make evaluations on a more micro basis by taking into account the effects of the relevant digital currency on the economic environments of the countries, monetary policies, and the attitudes of the citizens of the country toward this currency, and to develop the necessary suggestions, if any.



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## REFERENCES

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- Abogados, B. (2022). Developing a Mexico CBDC, Client Update, August 10<sup>th</sup>, 1-6, <https://berdeja.com.mx/memos/Developing%20a%20Mexico%20CBDC.AUG10.22.pdf>. (accessed May 13, 2023).
- Acar Balaylar, N. (2023). Central Bank Digital Money and the Efficiency of Monetary Policy. *Journal of Dogus University* 24 (1): 199-216.
- Adrian, T. and Mancini-Griffoli, T. (2021). A New Era of Digital Money. *International Monetary Fund Finance and Development*. <https://www.imf.org/external/pubs/ft/fandd/2021/06/online/digital-money-new-era-adrian-mancini-griffoli.htm>. (accessed May 13, 2023).
- Agur, I., Ari, A. and Dell’Ariccia, G. (2022). Designing Central Bank Digital Currencies. *Journal of Monetary Economics*, 125: 62-79.
- Alfar, AJK., Kumpamool, C. and Nguyen, DTK. (2023). The Determinants of Issuing Central Bank Digital Currencies. *Journal of Research in International Business and Finance*, 64 (101884): 1-13.
- Allen, F., Gu, X. and Jagtiani, J. (2022). Fintech, Cryptocurrencies, and CBDC: Financial Structural Transformation in China. *Journal of International Money and Finance*, 124 (102625): 1-13.
- Arner, D., Auer, R. and Frost, J. (2020). Stablecoins: Risks, Potential and Regulation. *Bank for International Settlements Working Papers, Monetary and Economic Department*, 905, 1-28. Available at <https://www.bis.org/publ/work905.pdf>. (accessed May 14, 2023).
- Bank for International Settlements. (2021). CBDCs: An Opportunity for the Monetary System. *Annual Economic Report*, June, 1-31, available at <https://www.bis.org/publ/arpdf/ar2021e3.pdf>. (accessed May 13, 2023).
- Bank for International Settlements. (2021). Central Bank Digital Currencies: Financial Stability Implications. In a Series of Collaborations from A Group of Central banks, Report No. 4, September, pp. 1-27.
- Bank for International Settlements. (2022). CBDCs in Emerging Market Economies. *Monetary and Economic Department*, Report No. 123, April, 1-210.
- Bank for International Settlements Innovation Hub. (2022). *International Settlements Using Multi-CBDCs (Project Dunbar)*, March, 1-61.
- Bank for International Settlements, SIX Group and Swiss National Bank. (2022). Project Helvetia Phase II Settling tokenized assets in wholesale CBDC, January, [https://www.snb.ch/en/mmr/reference/project\\_helvetia\\_phase\\_ii\\_report/source/project\\_helvetia\\_phase\\_ii\\_report.en.pdf](https://www.snb.ch/en/mmr/reference/project_helvetia_phase_ii_report/source/project_helvetia_phase_ii_report.en.pdf). (accessed June 23, 2023).
- Bank for International Settlements Innovation Hub. (2023). Project Icebreaker: Breaking New Paths in Cross-Border Retail CBDC Payments, March, 1-41. <https://www.bis.org/publ/othp61.pdf>. (accessed June 23, 2023).
- Bank of Canada Media Relations. (2023). Bank of Canada Launches Public Consultations on a Digital Dollar, <https://www.bankofcanada.ca/2023/05/bank-canada-launches-public-consultations-digital-dollar/May>. (accessed June 23, 2023).
- Bank of Jamaica. (2021). Ceremony for the First Minting of Jamaica’s Central Bank Digital Currency. Core Functions. <https://boj.org.jm/core-functions/currency/cbdc/ceremonial-first-minting-of-boj-cbdc/>. (accessed June 23, 2023).

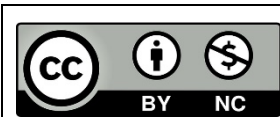
- Bank of Mauritius. (2023). The Central Bank Digital Currency: The Digital Rupee. Public Consultation paper, June 2, 1-4,
- Bank of Mauritius. (2023). The Central Bank Digital Currency: The Digital Rupee, Public Notice, June 2.
- Bank of Russia. (2020). A Digital Ruble. Central Bank of Russia Federation Consultation Paper, October, 1-44.
- Bank of Russia. (2023). Law on Digital Ruble Adopted. Press Event, July 11.
- Bank of Tanzania. (2023). Bank of Tanzania Progress on Central Bank Digital Currency. Public Notice, January 14. <https://www.bot.go.tz/Adverts/PressRelease/en/2023011413181519.pdf>. (accessed June 23, 2023).
- Barrdear, J. and Kumhof, M. (2022). The Macroeconomics of Central Bank Digital Currencies. *Journal of Economic Dynamics and Control*, 142 (104148), 1-24.
- Bech, M. and Garratt, R. (2017). Central Bank Cryptocurrencies. *BIS Quarterly Review*, September, 55-70.
- Bilotta, N. and Botti, F. (2021). CBDCs: The (Near?) Future of a Cashless Economy, In the Near (Future) Of Central Bank Digital Currencies: Risks and Opportunities for the Global Economy and Society. Peter Lang Academic Publishers, 7 (1).
- Boar, C. and Wehrli, A. (2021). Ready, steady, go? – Results of the Third BIS Survey on Central Bank Digital Currency. *Bank for International Settlements Papers, Monetary and Economic Department*, 114: 1-20.
- Bouchaud, M., Lyons, T., Olive, MS. and Timsit, K. (2020). Central Banks and the Future of Digital Money. A Practical Proposal for Central Bank Digital Currencies on the Ethereum Blockchain. Contributors: Adinolfi, S., Calmejjane, B., Dechaux, G. Fleuret, F. Grellet, V. Lia, J. and Singer, M., Consensus White Paper, 1-28.
- Carstens, A. (2018). Money in the Digital Age: What Role for Central Banks. *Bank for International Settlement, House of Finance, Goethe University, Frankfurt*, February 6, 1-10.
- Catalini, C. (2018). Blockchain Technology and Cryptocurrencies: Implications for the Digital Economy, Cybersecurity, and Government. *Georgetown J of International Affairs*, 19: 36-42.
- Central bank of the Turkish Republic. (2021). Press Release on the Central bank Digital Turkish Lira RandD Project, September 15, 40.
- Central Bank of the Turkish Republic. (2022). Use of Digital Turkish Lira, 29 December. Press Release, 55.
- Chapman, J. (2022). Discussion of “The Macroeconomics of Central Bank Digital Currencies”. *Journal of Economic Dynamics and Control*, 142 (104149), 1-3.
- Chen, H. and Siklos, PL. (2022). Central Bank Digital Currency: A Review and Some Macro-Financial Implications. *Journal of Financial Stability*, 60 (100985), 1-19.
- Citi GPS. (2023). Money, Tokens, and Games Blockchain’s Next Billion Users and Trillions in Value, Global Perspectives and Solutions, March, 1-161.
- Cunha, PR., Melo, P. and Sebastião, H. (2021). From Bitcoin to Central Bank Digital Currencies: Making Sense of the Digital Money Revolution. *Journal of Future Internet*, 13 (165), 1-19.

- Davoodalhosseini, SM. (2022). Central Bank Digital Currency and Monetary Policy. *Journal of Economic Dynamics and Control*, 142 (104150), 1-22.
- Deloitte. (2022). Central Bank Digital Currencies: Building Block of the Future of Value Transfer. 1-34. <https://www2.deloitte.com/content/dam/Deloitte/in/Documents/financial-services/infs-cbdc-noexp.pdf>. (accessed May 18, 2023).
- Fáykiss, P., Nyikes, A. and Szombati, A. (2022). CBDC – An Opportunity to Support Digital Financial Inclusion: Digital Student Safe in Hungary. *Bank for International Settlements Papers Chapters*, in: Bank for International Settlements (ed.), CBDCs in Emerging Market Economies, 123, 79-87.
- Geroni, D. (2021a). Understanding the Types of Central Bank Digital Currencies (CBDC). September, <https://101blockchains.com/types-of-central-bank-digital-currencies/>. (accessed February 18, 2023).
- Geroni, D. (2021b) Blockchain Solutions for Central Bank Digital Currency (CBDC). February, <https://101blockchains.com/central-bank-digital-currency-cbdc-blockchain/>. (accessed February 18, 2023).
- Grischencko, V., Ponomarenko, A. and Seleznev, S. (2023). A Feasible Approach to Projecting Household Demand for the Digital Ruble in Russia. *Bank of Russia Working Paper Series*, 108, 1-41.
- Han, X., Yuan, Y. and Wang, FY. (2019). A Blockchain-Based Framework for Central Bank Digital Currency. *IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI)*, 263-268.
- Hong Kong Monetary Authority. (2022). e-HKD: A Technical Perspective. Whitepaper in Collaboration with BSIH Hong Kong Centre, 1-49.
- Horvath, G. (2022). Monetary Sovereignty and Central Bank Digital Currency. *Public Finance Quarterly* (0031-496X) 67 (4): 539-552.
- Huang, Y. and Mayer, M. (2022). Digital Currencies, Monetary Sovereignty, and U.S.–China Power Competition. *Policy and Internet*, June, 1-24.
- International Monetary Fund. (2020). Digital Money across Borders: Macro-Financial Implications, *IMF Staff Reports*, October, 1-48.
- International Monetary Fund. (2022). Towards Central Bank Digital Currencies in Asia and the Pacific Results of A Regional Survey. *Fintech Notes*, September, 009, 1-40.
- International Monetary Fund. (2023). IMF Approach to Central Bank Digital Currency Capacity Development. *Policy Papers*, April, 1-22.
- Kim, YK. and Kwon, O. (2023) Central Bank Digital Currency, Credit Supply, And Financial Stability. *Journal of Money, Credit and Banking*, 55 (1), 297-321.
- Kosse, A. and Mattei, I. (2022). Gaining Momentum – Results of the 2021 BIS Survey on Central Bank Digital Currencies. *Bank for International Settlements Papers*, 125, 1-23.
- KPMG. (2020). A Global Look at Central Bank Digital Currencies from Iteration to Implementation. *The Block Research White Paper*, August 2020.
- Kumhof, M. and Noone, C. (2021). Central Bank Digital Currencies— Design Principles for Financial Stability. *Journal of Economic Analysis and Policy*, 71, 553-572.

- Ledger Insights. (2023). Jamaican Government to Incentivize JAM-DEX CBDC merchants. <https://www.ledgerinsights.com/jamaica-cbdc-incentivize-merchants-jam-dex/>. (accessed June 25, 2023).
- Lee, Y., Son, B., Park, S., Lee, J. and Jang, H. (2021). A Survey on Security and Privacy in Blockchain-Based Central Bank Digital Currencies. *Journal of Internet Services and Information Security*, 11 (3), 16-29.
- Li, Z., Yang, C. and Huang, Z. (2022). How Does The Fintech Sector React to Signals from Central Bank Digital Currencies?. *Finance Research Letters*, 50 (103308), 1-5.
- Lyons, RK. and Viswanath-Natraj, G. (2023). What Keeps Stablecoins Stable?. *Journal of International Money and Finance*, 131 (102777), 1-20.
- Mancini-Griffoli, T., Soledad Martinez Peria, M., Agur, I., Ari, A., Kiff, J., Popescu, A., Rochon, C. contributions from Fabio Comelli, Federico Grinberg, Ashraf Khan, and Kristel Poh (2018). Casting Light on Central Bank Digital Currency. *International Monetary Fund Staff Discussion Note*.
- Maynard, N. and Tetnowski, D. (2023) CBDCs A New Wave in Payments. *Juniper Research White Paper*, March 2023: 1-8.
- Mzoughi, H., Benkraiem, R. and Guesmi, K. (2022). The Bitcoin Market Reaction to the Launch of Central Bank Digital Currencies. *Research in International Business and Finance*, 63 (101800), 1-9.
- Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. <https://bitcoin.org/bitcoin.pdf>.
- National Bank of Georgia. (2023). Project DGEL. Public Note, February. <https://nbg.gov.ge/en/media/news/the-national-bank-of-georgia-advances-digital-lari-project-and-finalizes-expression-of-int>. (accessed October 25, 2023)
- Nepal Rastra Bank Currency Management Department. (2022). Central Bank Digital Currency (CBDC): Identifying Appropriate Policy Goals and Design for Nepal. A Concept Report (Released for Public Consultation), August, 1-78, <https://www.nrb.org.np/contents/uploads/2022/10/CBDC-for-Nepal.pdf>. (accessed June 19, 2023)
- Nolting, C., Heinz, G. and Köhling, S. (2020) Central Bank Digital Currencies: Money Reinvented. *Deutsche Bank Wealth Management CIO Special*, September, 1-15.
- Opare, EA. and Kim, AK. (2020). A Compendium of Practices for Central Bank Digital Currencies for Multinational Financial Infrastructures. *IEEE Access, Special Section on Blockchain Technology: Principles and Applications*, 8: 110810-110847.
- Ozili, PK. (2022). Can Central Bank Digital Currency Increase Financial Inclusion? Arguments for and Against. Sood, K., Balusamy, B., Grima, S. and Marano, P. (Ed.) *Big Data Analytics in the Insurance Market (Emerald Studies in Finance, Insurance, and Risk Management)*, Emerald Publishing Limited, Bingley, 241-249.
- Ozili, PK. (2023). ENaira Central Bank Digital Currency (CBDC) For Financial Inclusion in Nigeria. In *Springer Book titled: Digital Economy, Energy and Sustainability: Opportunities and Challenges*, 41-54. [https://doi.org/10.1007/978-3-031-22382-2\\_3](https://doi.org/10.1007/978-3-031-22382-2_3).

- Payment and Settlement Systems Department. (2023). Central Bank Digital Currency Experiments Results and Findings from “Proof Of Concept Phase 2”, Bank of Japan, May, 1-29. <https://www.boj.or.jp/en/paym/digital/dig230529a.pdf>. (accessed July 20, 2023).
- Payments Canada. (2017). Bank of Canada and R3 (2017) Project Jasper. White Paper, 1-67, [https://payments.ca/sites/default/files/2022-09/jasper\\_report\\_eng.pdf](https://payments.ca/sites/default/files/2022-09/jasper_report_eng.pdf). (accessed February 28, 2023)
- Perret, V. (2019). Money of the Digital Era, the Central Bank Opportunities, Risks and Impacts in Digital Currencies. Geneva: Observatoire de la finance, 1-40.
- Popowicz, JE. (2023). The Winners of the 2023 Fintech Regtech Global Awards. <https://www.centralbanking.com/awards/7958962/the-winners-of-the-2023-fintech-regtech-global-awards>. (accessed July 18, 2023).
- Presidency of the Republic of Turkey, Presidency of Strategy and Budget (2020). Eleventh Development Plan (2019-2023), 100<sup>th</sup> Year Turkey Plan, Ankara, Available via [https://www.sbb.gov.tr/wp-content/uploads/2022/07/Eleventh\\_Development\\_Plan\\_2019-2023.pdf](https://www.sbb.gov.tr/wp-content/uploads/2022/07/Eleventh_Development_Plan_2019-2023.pdf). (accessed May 15, 2023).
- Priyadarshini, D. and Kar, S. (2021). Central Bank Digital Currency (CBDC): Critical Issues and The Indian Perspective. IEG Working Papers, 444, 1-18.
- Ree, J. (2023). Nigeria’s eNaira, One Year After. International Monetary Fund Working Papers, WP/23/104, 1-43.
- Rehman, MA, Irfan, M., Naeem, MA., Lucey, B. and Karim, S. (2023). Macro-Financial Implications of Central Bank Digital Currencies. *Research in International Business and Finance*, 64 (101892), 1-12.
- Reserve Bank of Australia and DFCRC. (2022). Australian CBDC Pilot for Digital Finance Innovation. White Paper, September, 1-14, [rba.gov.au/payments-and-infrastructure/central-bank-digital-currency/pdf/australian-cbdc-pilot-for-digital-finance-innovation-white-paper.pdf](https://www.rba.gov.au/payments-and-infrastructure/central-bank-digital-currency/pdf/australian-cbdc-pilot-for-digital-finance-innovation-white-paper.pdf). (accessed October 4, 2023).
- Rojas-Breu, M (2022). Discussion of “Central Bank Digital Currency and Monetary Policy”. *Journal of Economic Dynamics and Control*, 142, (104151): 1-3.
- Sethaput, V. and Innet, S. (2023). Blockchain Application for Central Bank Digital Currencies (CBDC). *Cluster Computing*, Springer, Published online on January 16.
- Shen, W. and Hou, L. (2021). China’s Central Bank Digital Currency and Its Impacts on Monetary Policy and Payment Competition: Game Changer or Regulatory Toolkit?. *Computer Law and Security Review*, 41 (105577), 1-12.
- Soderberg, G. in collaboration with Marianne Bechara, Wouter Bossu, Natasha Che, Sonja Davidovic, John Kiff, Inutu Lukonga, Tommaso Mancini-Griffoli, Tao Sun, and Akihiro Yoshinaga. (2022). Behind The Scenes Of Central Bank Digital Currency Emerging Trends, Insights, And Policy Lessons. *Fintech Notes (International Monetary Fund)*, 004, February, 1-27.
- Sveriges Riksbank. (2023). E-Krona Pilot, Phase 3. E-krona Report, 1-34. <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2023/e-krona-pilot-phase-3.pdf>. (accessed March 5, 2023).
- Syed, M. (2023) The Design and Deployment of CBDCs on Blockchain Based Technology, <https://www.linkedin.com/pulse/design-deployment-cbdcs-blockchain-based-technology-mustafa-syed/>. (accessed June 11, 2023).

- Tan, B.J. (2023). Central Bank Digital Currency and Financial Inclusion. International Monetary Fund Working Paper, WP/23/69, March 2023, 1-52. <https://www.imf.org/en/Publications/WP/Issues/2023/03/18/Central-Bank-Digital-Currency-and-Financial-Inclusion-531104>. (accessed October 14, 2023).
- Tata, F. (2023). Proposing an Interval Design Feature to Central Bank Digital Currencies. Research in International Business and Finance, 64 (101898), 1-13.
- Terták, E. and Kovács, L. (2022). The Motives for Issuing Central Bank Digital Currency and the Challenges of Introduction Thereof. Public Finance Quarterly, 491-505.
- Turkey Informatics Foundation. (2022). New Forms of Trade: Centre Bank Evaluation Report on Digital Currency. Blockchain Turkey, Banking, Finance and Insurance Working Group, November, 1-23. <https://bctr.org/wp-content/uploads/2022/11/MBRaporuV03.pdf>. (accessed March 15, 2023).
- Williamson, S.D. (2022). Central Bank Digital Currency and Flight to Safety. Journal of Economic Dynamics and Control, 142 (104146), 1-25.
- Xia, H., Gao, Y. and Zhang, Z.J. (2023). Understanding the Adoption Context of China's Digital Currency Electronic Payment. Journal of Financial Innovation, 9 (63), 1-27.
- Zhang, T. and Huang, Z. (2022). Blockchain and Central Bank Digital Currency. ICT Express, 8, 264-270.
- <https://www.atlanticcouncil.org/cbdctracker/> (accessed February 15, 2023).
- <https://cbdctracker.org/> (accessed February 28, 2023).
- <https://cbdctracker.org/currency/sweden-e-krona>. (accessed March 5, 2023).
- <https://cbdctracker.org/currency/israel-e-shekel>. (accessed March 11, 2023).
- <https://www.centralbanking.com/awards/7958962/the-winners-of-the-2023-fintech-regtech-global-awards>. (accessed August 13, 2023).
- <https://data.worldbank.org/country>. (accessed October 24, 2023).
- <https://www.ledgerinsights.com/jamaica-cbdc-incentivize-merchants-jam-dex/>. (accessed June 19, 2023)



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