DOI:10.17951/h.2023.57.2.67-86

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LVII, 2 SECTIO H 2023

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Central Bank Digital Currency (CBDC) – Barriers to Its Introduction

Keywords: central bank digital currency; digital money; CBDC

JEL: G21; E50; E42

How to quote this paper: Nocoń, A. (2023). Central Bank Digital Currency (CBDC) – Barriers to Its Introduction. *Annales Universitatis Mariae Curie-Skłodowska, sectio H – Oeconomia*, *57*(2), 67–86.

Abstract

Theoretical background: The beginning of the third decade of the 21st century brought a dynamic development of new technologies, intensifying the ongoing process of digitalization of the global economy. Among these changes, one of the undoubtedly noticeable areas that are developed both on theoretical and practical grounds is the central bank digital currency (CBDC). It is a new – different from cash – currency issued by the monetary authorities, considered as a response to the development of private virtual currencies, which is aimed at the same time to improve the circulation of money. An increasing number of central banks are considering issuing their own CBDC. According to the BIS studies, in 2021 nine out of ten central banks actively research implementation of a digital currency. This number is constantly growing. More and more monetary authorities are at an advanced stage of CBDC work, 26% of central banks already running pilot tests (compared to only 8% in 2018).
Purpose of the article: The main aim of the article is to identify barriers to the central bank digital currency introduction as well the case study analysis of the current involvement of selected central banks in the process of its implementation.
Research methods: The main research method used in the conducted empirical research is the case study analysis of selected central banks that have undertaken works on the CBDC implementation. The research verifies the main hypothesis that despite growing involvement of central banks in the work for the issue of CBDC, its barriers and limitations are large enough to inhibit practical implementation.

Main findings: The results indicated that such barriers as limited validity period, lack of anonymity and full control of a central bank over its use may significantly limit further monetary authorities' work on its implementation.

Introduction

Central Bank Digital Currency (CBDC) is a new, digital form of money. CBDC relies on the fact that a central bank issue money but not in its paper form. Moreover, it would not replace cash. Instead, it issues digital money that streamlines cashless transactions. In recent years, work on the implementation of digital money has gained momentum. This is due to several reasons. First, the crisis induced by the COVID-19 pandemic has caused a shift in payment habits towards digital and contactless payments as well as e-commerce. This was due to the belief (later refuted) that banknotes transmit infections, which resulted in a decrease in the use of cash and an increase interest in non-cash payments. Secondly, it was influenced by the dynamic development and further increase of value of cryptocurrencies, including stablecoins. Thirdly, an important driver of CBDC growth was the development of modern technologies (DLT/blockchain) as well as growing popularity of virtual currencies.

Currently, over 90 countries around the world, which represent over 90% of global GDP, have undertaken or are undertaking work to issue CBDC. Four of them – the Bahamas, Eastern Caribbean, Nigeria and Jamaica – have fully launched their own central bank digital currency. The growing interest on the essence of central bank digital money, its advantages, barriers and challenges faced by monetary authorities, as well as possible models of CBDC issuance has become the main premise to undertake this problem in the article. The main aim of the article is to identify barriers to the central bank digital currency introduction as well the case study analysis of the current involvement of selected central banks in the process of its implementation. The research verifies the main hypothesis that despite growing involvement of central banks in the work for the issue of CBDC, its barriers and limitations are large enough to inhibit practical implementation.

The paper presents all the so far findings about the new problem in financial world, which is the central bank digital currency, as well as explains its implementation models and the role of central bank in this process. This aspect is so far rarely undertaken in the scientific publications, which undoubtedly constitutes a significant contribution to the current state of knowledge. Moreover, the important contribution of the article is the case study analysis, which illustrates the current involvement of the selected central banks in the world in the CBDC project. It provides readers a clear brief of where we are, what can we expect in the near future and what is the central banks' attitude to its issuance.

The article has a theoretical and empirical nature. The first section includes the broad, international literature review that presents the main finding about the

CBDC – methods of its definition and interpretation, main objectives of its issuance and differences from other types of money. The second part of the literature studies explains types and models of CBDC implementation, paying particular attention to the detail and wholesale types of CBDC as well as account- and token-based models. The second section of the paper provides the characteristic of methodology used in the empirical research. Then, the third section presents the obtained results of the conducted empirical research. The final section is discussion and conclusion, which summarizes the whole considerations undertaken in the paper.

The following research methods were used in the article: literature studies, document analysis method, case study analysis method and synthesis method.

Theoretical background

General findings about CBDC

The concept of CDBC exists in the financial space for almost a decade (Zieliński, 2015). However, this term is still considered as relatively new and so far has not been given a single, commonly accepted definition. CBDC is one of the forms of money issued in digital form by a central bank that might be used as legal tender. CBDC is an electronic form of traditional currencies of individual countries (e.g. digital yuan, euro, pound or dollar), which assumption is to use it as a form of payment in transactions, similarly to cash or deposits. Bjerg (2017, p. 23) indicates that CBDC is a liability for publicly available deposits, which is registered electronically in central bank's balance sheet. Bech and Garratt (2017, pp. 55–70) add that the main assumption of the central bank digital currency is to make it available to all interested entities operating in the economy, as is the case with cash. Bank for International Settlements in Basel (BIS, 2018) defines CBDC as a new form of publicly available central bank money. In its opinion, it is an innovation for entities which, in the majority of functioning monetary systems, do not have access to reserves on accounts, maintained by a central bank. In turn, Mancini-Griffoli et al. (2018, p. 7) from the International Monetary Fund (IMF) emphasizes that it is a digital version of cash that is issued and regulated by central banks. Table 1 presents the CBDC definitions proposed by the main central banks in the world.

Table 1. CBDC definitions of the main central banks in the world

Central bank	Definition
Federal Reserve System	It is a digital liability of a central bank that is widely available to the general public. A CBDC is the safest digital asset available to the general public, with no associated credit or liquidity risk.
Bank of England	Is money that a country's central bank can issue. It's called digital (or electronic) because it isn't physical money like notes and coins. It is in the form of an amount on a computer or similar device. It is an electronic form of central bank money that could be used by households and businesses to make payments and store value.

Central bank	Definition
European Central Bank	It is an electronic form of central bank money accessible to all citizens and firms. A digital money would be introduced alongside cash, it would not replace it. It denotes a liability of the system recorded in digital form as a complement to cash and central bank deposits.
Bank of Japan	It is a new form of digital money issued by a central bank. CBDC would be different from cash in that it is issued in digital format. CBDC is issued as central bank liabilities and is held as assets by entities other than the central bank. CBDC is transferred between individuals and firms in exchange for goods and services, thereby functioning as a payment instrument. Also, by CBDC being issued denominated in their home countries' fiat currency, it functions as a unit of account in a nation's economy.
Swiss National Bank	It is monetary value stored electronically (digitally, or as an electronic token) that represents a liability of the central bank and can be used to make payments.

Source: Author's own study based on: (Federal Reserve System, 2022; Bank of England, 2020; ECB, 2020; Bank of Japan, 2022; Baeriswyl et al., 2021).

The main objective of issuing digital currency is to provide the society access to a safe form of money in the era of progressive digitization. In a situation where CBDC is made available for use in retail payments, this money will meet the following specific objectives (Figure 1).

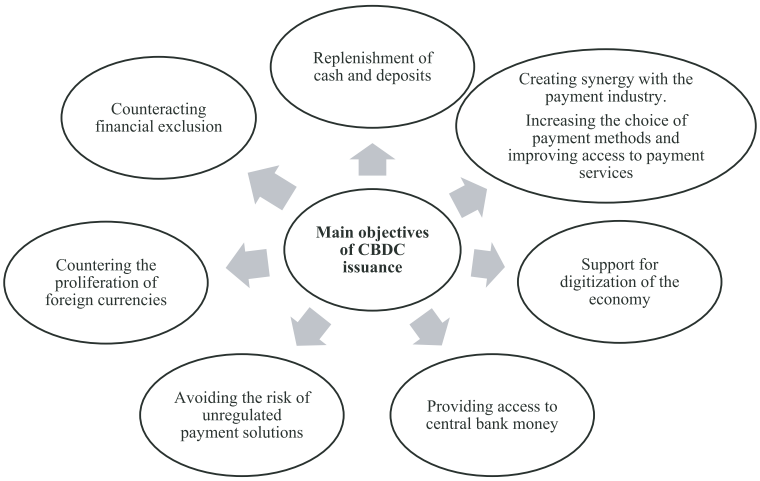

Figure 1. Main objectives of CBDC issuance

Source: Author's own study.

However, the objectives of central bank digital currency issuance may vary from country to country. This is due to macroeconomic conditions, specificity of the market and a central bank itself. In addition, depending on the purpose of CBDC issuance, digital money can be designed in many ways.

CBDC is issued parallel to the current money issued by monetary authorities. It does not mean withdrawal of the paper money. So far, central banks have issued two types of money – cash (banknotes and coins) and electronic central bank deposits – reserves or settlement balances. Cash money is issued in physical form and

widely available, while central bank reserves are non-cash and usually only available to qualifying financial institutions (mainly banks). Central bank digital currency is another modern form of central bank money. It is, therefore, an alternative to cash and non-cash money issued so far. However, similarly to non-cash money (i.e. funds accumulated on accounts in a central bank), digital currency is issued only in electronic form.

CBDC is a central bank liability denominated in an existing unit of account that serves primarily as a medium of exchange but also (though to a lesser extent) store of value. What distinguishes CBDC from cash is not only its digital form, but also possibility of programming, due to the use of automatic execution of transactions after meeting certain conditions (smart contracts), possibility of easy use for payments, anonymity and common availability.

Digital currency is a new form of central bank money, also different from the previously known digital forms of money issued by private entities, e.g. bank money (deposits), electronic money or virtual currencies (see Table 2). Although CBDC operates in the virtual world, it should not be equated with virtual currencies or cryptocurrencies. Cryptocurrencies are not electronic money within the meaning of the law, but only a digital representation of the contractual value among its users, they are also not issued and guaranteed by any central bank in the world. They are decentralized, which means that they are not subject to one specific entity, but are distributed over various networks. In turn, CBDC is a type of digital currencies that are issued by central banks, centralized and remain under their complete control.

Table 2. Forms of money according to the issuing entity

FORMS OF MONEY	*Private sector money*	Bank deposits
		Electronic money (value on electronic money accounts or saved on payment instrument/server)
		Virtual currencies (e.g. bitcoin or ethereum)
		Tokenized financial assets*
		Asset-based tokens (*stablecoins*)
	Central bank money	Cash
		Funds on required reserve accounts and current accounts
		Central Bank Digital Currency (CBDC)

*financial assets that have undergone the process of tokenization, i.e. transferring the value of assets to the digital world, due to the use of Blockchain technology

Source: Author's own study.

Central bank digital currency also differs from existing forms of non-cash payment instruments, such as: bank transfer/credit transfer, direct debits, card payments or e-money, because it represents a direct claim against a central bank, and not an obligation of a private financial institution. This type of risk-free claim also distinguishes CBDC from other private digital tokens (stablecoins, such as Tether) (Boar & Wehrli, 2021, p. 4). Stablecoin, in turn, is a type of cryptocurrency, more precisely a payment token, issued by private entities, which value is permanently based on the value of a specific traditional fiat currency (usually the US dollar, less often euro or yen) or a basket of these currencies, or other goods, e.g. gold, silver or oil. Its value, therefore, follows the price of one specific underlying asset. Thus, stablecoins "import" stability from traditional currencies issued by central banks, which makes them a less attractive, a kind of "secondary" asset (NBP, 2021, p. 31).

Although CBDC has both its supporters and many opponents, it should be distinguished many benefits of its issue, such as (Dyson & Hodgson, 2016, pp. 1–2):

– extending the range of monetary policy instruments used by central banks,

– increasing safety of the financial system,

– promoting competition and innovation in payment systems,

– maintaining income in the form of a mint annuity in the conditions of limiting the issuance of cash,

– solving problems related to limiting the creation of money as a result of non-bank financing,

– counteracting financial exclusion.

On the other hand, barriers or risks arising from the implementation of the central bank digital currency cannot be ignored. They are as follows (Keister & Sanches, 2023, pp. 404–431; BIS, 2021; Paragon bank, 2022):

– direct competition for banks and an increase in the cost of banks' financing – if along with an increase in the CBDC popularity, deposits currently held in commercial banks are replaced with the central bank digital currency, this will put pressure on banks, crowd out deposits and fear of losing funding for their activities; as a result, this may lead to a situation in which banks will not be able to grant loans, and thus finance households' and enterprises' needs, which will limit the scale of investments,

– traceability and lack of anonymity – in principle, every transaction made via CBDC is registered, which results in the loss of users privacy; this is in complete opposition to the establishment of most cryptocurrencies and cash, which the main feature and advantage is anonymity of their users,

– threat to privacy – along with the CBDC implementation, central banks can interfere with users' private transactions to monitor and combat financial crimes such as money laundering,

– high risk of cyberattack – the central bank digital currency may attract cybercriminals who want to extort money from one source,

– limiting the freedom – a central bank may limit freedom of users, e.g. by prohibiting the use of CBDC on buses and trains, which will effectively limit their

freedom to travel as they wish, or introduce a ban on spending digital money on fuel to reduce the amount of exhaust gases into the atmosphere; in this way, the monetary authority can stimulate decisions and direction of spending as well as allocation of digital funds by citizens,

– fixed expiry date – if the CBDC has a specific expiry date, after that time digital currency becomes useless.

Models of CBDC implementation

Works on CBDC implementation concentrate both on the adopted type as well as model of its issue. There are two main types of central bank digital currency (NBP, 2021, p. 8):

1) retail CBDC – widely available for retail payments, which is a substitute for cash and deposits in commercial banks, used for everyday transactions,

2) wholesale CBDC – for large-value payments, which is a banking sector instrument, a means of settlement between a central bank and commercial banks, also used for international transactions, constituting an alternative to funds on current accounts in a central bank.

Furthermore, there are considered two main models of CBDC implementation:

– account-based model – a model based on accounts maintained for individuals and business entities in a central bank,

– token-based model – a model based on the emission of tokens – digital value representatives.

In the account-based model a central bank is responsible for the whole payment infrastructure (which is centralized), as well as for maintaining the value of the issued money. All transaction data is collected on a central account. Access to the CBDC is available through hardware and software, similar to mobile banking. The CBDC "purchase", thus, its possession, takes place through conversion of money from a holder's account to a CBDC account held at a central bank. In turn, all devices (smartphones with an application) do not collect any asset data, they are only an access point to a central database on funds and transactions (see Figure 2) (Norges Bank, 2018, 2019; PKO BP, 2021, p. 4).

In the token-based model a central bank is responsible for money and security of issuance associated with it – as in the issue of cash. On the other hand, commercial banks are responsible for technological solutions that enable distribution of CBDC between their clients. Customers can use money held at banks to purchase CBDC. However, the "purchase" takes place in a central bank. Therefore, this model allows for the transfer of value using a smartphone application, but without participation of the central transaction partner (see Figure 3) (Auer & Boehme, 2020, pp. 85–100; Norges Bank, 2018, 2019; PKO BP, 2021, p. 4).

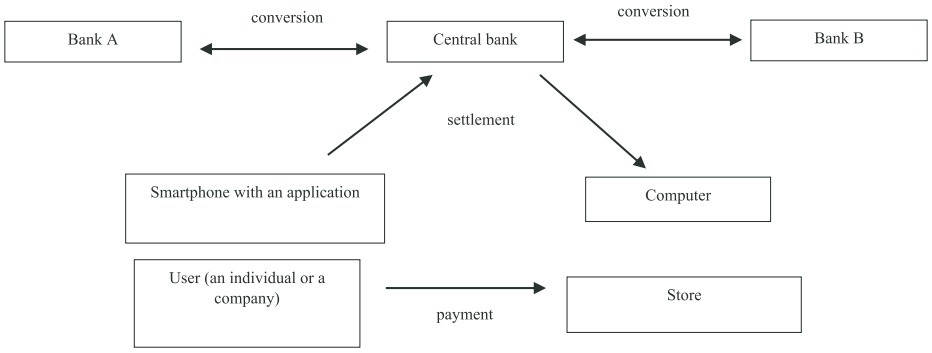

Figure 2. Account-based model of CBDC

Source: Author's own study based on: (Norges Bank, 2018, 2019).

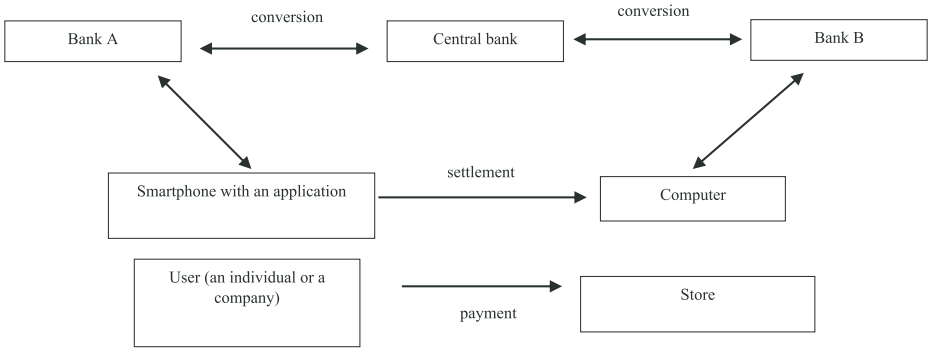

Figure 3. Token-based model of CBDC

Source: Author's own study based on: (Norges Bank, 2018, 2019).

In the case of retail CBDC, both models of its implementation are considered. In turn, CBDC for large-value payments can only be issued in a token-based model (Norges Bank, 2018, 2019; PKO BP, 2019, p. 4). Both of the above models of digital money implementation can be created based on the high technology used in existing payment systems (with central settlement), or a new technology, mainly distributed ledger technology – DLT (with decentralization of processes, including settlement). However, the adoption of a specific model will determine further details of its implementation and possible consequences.

Literature review

The issue of central bank digital currency, as it was indicated, is relatively new, which means that the literature in this area is still quite limited. However, the conducted literature review indicates that there are few scientific areas related to CBDC. An important research trend in the literature on CBDC is its impact on financial stability, primarily by affecting banks' financing, their lending activity, market discipline and vulnerability to bank panic, and in macroeconomic terms also implications for the prosperity and economic activity of the country in which it is introduced (BIS, 2018). There is considerable literature on the potential impact of CBDC on bank financing. BIS (2018), Fernández-Villaverde et al. (2020), Keister and Sanches (2019) indicate that CBDC structurally reduces commercial banks' funding, because users are more likely to choose liquidity and convenience provided by the central bank digital currency, that is why they refer to it as a safe haven asset. This is confirmed by Williamson (2019), who also adds that CBDC, unlike cash, is resistant to theft and limited availability – as in the case of bank deposits. Moreover, Chiu et al. (2019) as well as Kumhof and Noone (2018) argue that in an imperfectly competitive deposit market, the existence of CBDC forces commercial banks to adjust an interest rate on deposits to a level that will allow them to be retained in banks, which ultimately translates into an effect encouraging depositors to increase their savings. On the other hand, a change in the interest rate on deposits affects deterioration of the banks' financing conditions and changes in the scope of their lending, including terms and interest rates of granted loans. As a result, implementation of CBDC may change both the amount of deposits accepted by banks and the size of granted loans. In this respect, this literature trend may raise concerns that the introduction of CBDC may replace the main source of funding for banks and cause disintermediation of commercial banks, which in turn will lead to a decrease in their lending.

In addition, Andolfatto (2020) states that the introduction of an interests on CBDC will increase financial inclusion especially where the banking sector is not perfectly competitive, while reducing the demand for cash. Due to the competitive pressure exerted by the CBDC and the more favorable deposit offer of commercial banks, people who have not yet been banked will be encouraged to take advantage of access to the banking sector. Thus, implementation of digital currency may lead to the expansion of banks' depositor base.

Many studies also prove that CBDC can affect profitability of banks and their lending. If commercial banks react to the introduction of digital currency by becoming more dependent on market funding, then (depending on the type of market funding) there will be transformations in bank maturity and an increase in liquidity risk due to greater dependence on less stable sources of funding. In turn, Mancini-Griffoli et al. (2018) indicate that changes in market financing may increase the pro-cyclicality of bank lending. They confirm the previously presented conclusions that if banks increase an interest rate on deposits in order to keep them relative to the competitive CBDC,

lending may decrease, while some loans – those that were profitable at a lower cost of obtaining capital – will turn out to be unprofitable. Moreover, Agur et al. (2022) and Mancini-Griffoli et al. (2018) note that banks with a more stable market position may try to compensate higher interest rates on deposits by raising interest rates on loans, without major damage to the scale of their lending activity. In turn, those with a weaker market position may struggle with a decrease in demand for credit money along with an increase in interest rates or maintain interest rates while remaining on the verge of profitability. Piazzesi and Schneider (2020) also add that such a reduction in lending will translate into a deterioration in banks' profitability and stability, and as a result, a weakening of economic activity and a decline in prosperity in countries that have introduced a digital currency. On the other hand, the model of Chiu et al. (2019) calibrated for the US economy shows the positive impact of CBDC on the scale of granted loans. They indicate that banks' lending activity after implementation of the central bank digital currency may even increase by as much as 3.55% with a properly selected interest rate. They also add that if the CBDC interest rate is lower than an interest rate on bank deposits, this does not affect their deposit activities. If the interest rate of CBDC is only slightly higher than that of deposits, banks will respond by increasing an interest rate on deposits and loans. Only when the interest rate of the digital currency is too high, the introduction of CBDC has a negative impact on the deposit and lending activities of banks. Brunnermeier and Niepelt (2019, pp. 27–41) also note that implementation of CBDC does not have to affect the equilibrium allocation if a smaller scale of bank deposits accepted is replaced by a funding stream from a central bank. Therefore, a central bank will finance the missing capital needs of commercial banks resulting from the outflow of some deposits to CBDC. This emphasizes even more significantly the role of the "lender of last resort" performed by the monetary authority. These conclusions are confirmed by the results obtained by Fernández-Villaverde et al. (2020), who built a bank run model as it was done by Diamond and Dybvig (1983, pp. 401–419), showing that implementation of CBDC has no effect on the deposits allocation. What is more, they proved that the existence of CBDC may reduce the likelihood of bank runs.

Some studies also indicate that CBDC may increase vulnerability of depositors to systemic banking crises by facilitating transfer of deposits. While availability of CBDC may not have a major impact on individual banks, because currently it is already possible to digitally and instantly transfer money between a "weaker" and a "stronger" bank, in the event of a systemic banking crisis, transfers from bank deposits to CBDC would be associated with lower costs transactions than those related to cash withdrawals (including going to an ATM or waiting in line) (Kumhof & Noone, 2018; Carstens, 2019).

The second important research trend on CBDC focuses on the provision of public and private money, and possibility of using CBDC as a means of transmitting monetary policy directly to market participants, and ultimately maintaining financial stability. CBDC as a new form of central bank money can be an additional tool of their monetary policy. A central bank will have an additional tool to directly influence portfolio choices of market participants. Barrdear and Kumhof (2016) examined the long-term and

cyclical effects of CBDC from a macroeconomic point of view. Based on a dynamic stochastic general equilibrium (DSGE) model with sticky prices and adjustment costs, they proved that the introduction of CBDC lowers interest rates and distorts taxes, thus increasing long-term GDP. Moreover, during recession, countercyclical CBDC issuance may lead to a smaller fall in GDP in response to a liquidity demand shock. Then a central bank can increase the amount of CBDC that households demand. The reduction in economic activity is then less severe, mitigating the decline in spending and thus welfare.

Research methods

The conducted empirical research mainly included the case study analysis of selected monetary authorities in the world. Their purpose was to identify a degree of involvement of the analyzed central banks in the process of preparation and issue of the central bank digital currency. The study analyzed both central banks that have already started the CBDC issuance process, as well as those that are working on its implementation at various levels. In the first stage of the empirical research, the main objectives guiding the issuance of CBDC by individual central banks were analyzed. The second stage concerned a review of experiences and challenges faced by central banks, both at the stage of preparatory work as well as practical implementation of CBDC. In the third stage of the empirical research, the state of work on digital money on a global scale and a degree of involvement of monetary authorities in this process were examined. Additionally, the following research methods were used: observation method, documents analysis method and synthesis method.

Results

Conceptual work related to the issuance of digital money are carried out by monetary authorities around the whole world. Some central banks and international institutions are only at the preliminary stage of implementing analytical projects, which results are published in special reports on CBDC. While other central banks, especially those in emerging economies, have decided to go a step further and implement some form of digital money. There are currently four retail – widely available CBDC in the world – in the Bahamas, Eastern Caribbean, Nigeria and Jamaica. Moreover, 28 pilot programs are underway, and 90 central banks, which countries account for 90% of global GDP, have officially announced work on their own digital money.

However, the real reasons for individual central banks' interest in the issue of CBDC are different (Figure 4). Most of them declare that undertaking analytical and research work was a response to the dynamic development of modern technologies (DLT/blockchain), growing popularity of private virtual currencies, development of

innovations in the area of payments, adapted to needs of the digital economy and decline in the importance of cash in payment transactions.

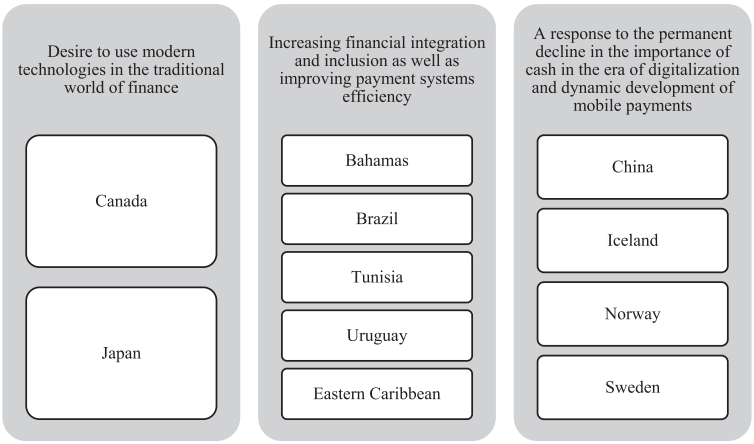

Figure 4. Main reasons for undertaking conceptual work on CBDC in individual countries

Source: Author's own study.

The first work in the world on the concept of issuing central bank digital currency was undertaken in 2014 by the People's Bank of China. After that, many other monetary authorities followed the Chinese experience, such as central bank of the United Kingdom (2015), Canada (2016), Singapore (2016) and Sweden (2017). They were soon joined also by other central banks from around the world, including: Denmark, Hong Kong, Japan, Norway, Israel, euro area, Uruguay and Ukraine. However, they recognized that in the CBDC issuance process, solutions applied in the case of virtual currencies issued by private entities cannot be directly used. Although they have many advantages, including indisputability of the concluded transaction, data integrity or transparency, it turned out that they also have significant limitations – for example, in terms of transaction speed, scalability or cost effectiveness, which resulted in the need to introduce own solutions, adapted to central bank's needs and its digital money.

Experiences and challenges faced by individual countries and their central banks, as well as factors that drive them to implement digital money, are very different. The Swedish central bank, which is at the forefront of the development of central bank digital currency, started work on CBDC in 2017 due to the fact that Sweden is a country where cash accounts for only about 1% of GDP, while a share of retail payments made in cash is 9% (Sveriges Riksbank, 2023a). No other country in the world has so little physical money in circulation. Many retail and service stores refuse to accept cash. Therefore, consumers independently or forced by the existing situation choose non-cash payment instruments, and digital money might be an alternative for them. In 2021, Sweden started a pilot phase in which the issuance of CBDC – *e-krona* was tested, according to a token-based model. In April 2022, the

second stage of the project was completed, under which CBDC offline functionalities and a degree of integration of banks and other payment service providers with the digital currency system were verified. In 2023, the Riksbank continued its work on CBDC by analyzing the impact of the *e-krona* on the Swedish economy, current mandate of the central bank, and identifying legal changes needed for its issuance as well as testing technical solutions of its implementation (Sveriges Riksbank, 2023b).

In China, along with very dynamic development of mobile payments, this market has been dominated by two operators – Alipay and WeChat Pay – which together have an 85% share in non-cash payments market (Żak, 2021). The work undertaken by the central bank of China in favor of CBDC were motivated by the desire to provide a solution dedicated to all citizens, including those unbanked and technologically excluded. The central bank also wanted the digital yuan to ensure the sovereignty of the Chinese currency, help maintain stability and increase the resilience of the payment system (People's Bank of China, 2021).

Central bank of the Bahamas started work on CBDC – *sand dollar* – due to the need to modernize their payment system, which infrastructure was affected by the hurricanes effects. This is a continuation of the Bahamian Payments System Modernization Initiative (PSMI), which began in the early 2000s. Its goal is to provide a modern, effective payment infrastructure and to increase a level of banking in the society (Central Bank of the Bahamas, 2019). The state of work on a widely available CBDC in the world in 2022 is presented in Figure 5.

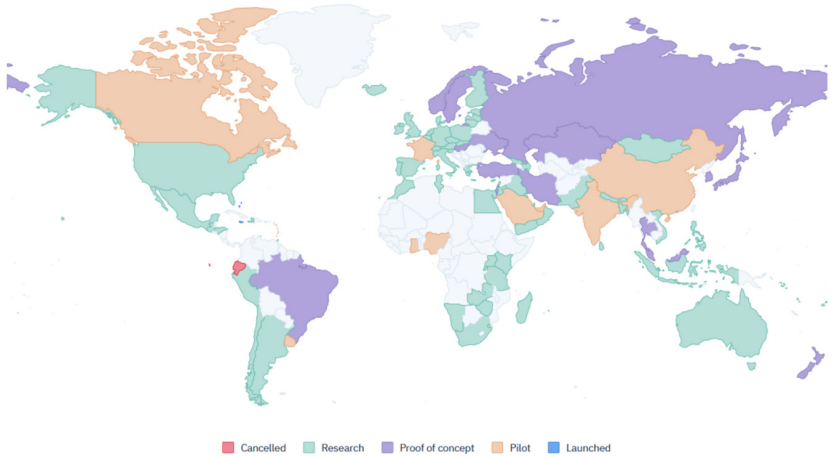

Figure 5. State of work on widely available CBDC in the world (in 2022)

Source: (CBDCtracker, 2023).

An important driver for further development of work on CBDC around the world was the Facebook announcement published in June 2019 of plans to implement a virtual currency in the form of digital stablecoins, which would be based on official

currencies or a basket of currencies. Originally, this money was called "Libra", then renamed "Diem", but in January 2022 the project was suspended. Regulators saw in it a threat related to Facebook's excessive control over the cryptocurrency and other controversial issues related to the financial system.

Research carried out by the Bank for International Settlements (BIS) in Basel indicate that in 2021, 90% of the 81 surveyed central banks in the world were working on the concept of CBDC issuance (Figure 6). They represent both developed as well as emerging and developing countries (Kosse & Mattei, 2022).

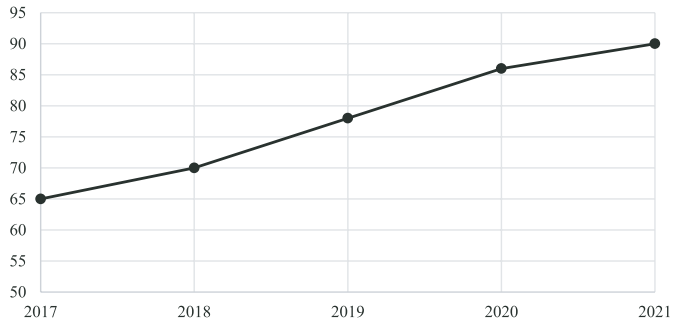

Figure 6. Proportion of central banks analyzed in the survey with a digital currency (CBDC) project (%)

Source: (Kosse & Mattei, 2022).

All these central banks are interested in implementing CBDC in retail form, or for both retail and wholesale form. However, none of them is limited only to the implementation of wholesale CBDC. In addition, work on retail CBDC is at a more advanced stage than work on wholesale digital money. Almost one-fifth of central banks are developing or testing retail CBDC, which is twice as many as those that are piloting wholesale CBDC (Figure 7) (Kosse & Mattei, 2022).

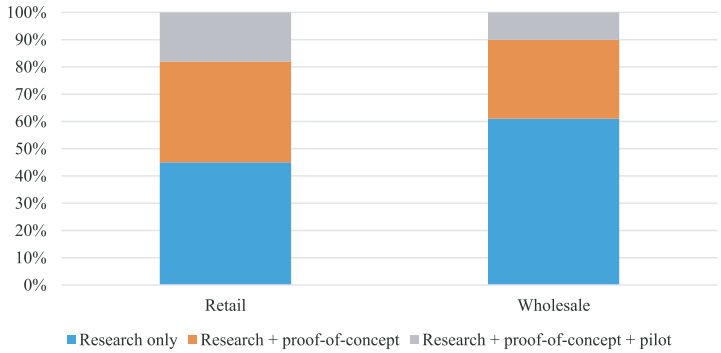

Figure 7. Focus of work by CBDC project in 2021 (%)

Source: Author's own study based on: (Kosse & Mattei, 2022).

Systematically conducted BIS survey also shows that every year more and more central banks are at an advanced stage of work on their own digital money. It is especially seen after the outbreak of the pandemic crisis, which intensified these research among all central banks. In 2020, 14% of the analyzed monetary authorities were at the stage of implementing pilot projects (Boar & Wehrli, 2021). A year later – in 2021 – this percentage increased to 26% (Figure 8). In turn, more than 62% of central banks conducted proofs-of-concept experiments (Kosse & Mattei, 2022).

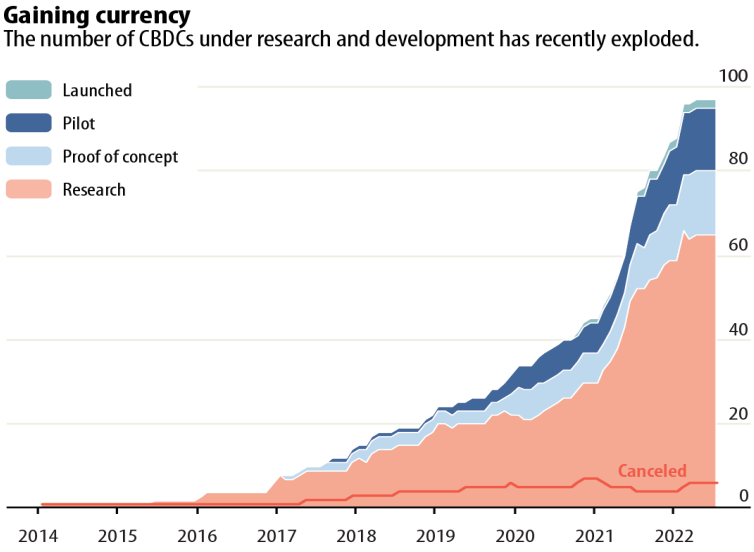

Figure 8. The number of CBDC under research and development (in July 2022)

Source: (Stanley, 2022).

However, it is difficult for central banks to indicate the specific date of the CBDC issue. More than half of them declare that they are considering such a possibility in the foreseeable future. Approximately 68% of the surveyed central banks believe they are likely to issue retail CBDC in the short- or medium-term. This probability is higher in emerging and developing economies than in highly developed countries (Kosse & Mattei, 2022).

It is worth emphasizing that central banks' activities in this field are strongly supported by international bodies and institutions. Bank of England indicates that the digital money – unlike private virtual currencies – performs all the classic functions of money (including a medium of exchange, a measure of value and a means of hoarding), is safe for citizens, and therefore its implementation may be not only a possibility, but necessary in the near future.

In October 2020, the Bahamas issued the world's first central bank digital currency, which is called *sand dollar*. It was an equivalent to the paper dollar issued

by that country, but only in the form of electronic notation. Along with the issue, all inhabitants of the islands gained access to the digital currency through a mobile application or a payment card. However, they were still free to use cash. The issue of CBDC enabled thousands of poor citizens, who had not yet used a banking system, to join the economy, and, thus, financial inclusion, but also to strengthen security against money laundering or illegal business activity. In turn, data from the CBDC system regarding users' income and expenses could be used, for example, when applying for microloans (Central Bank of the Bahamas, 2019). Shortly thereafter, the Eastern Caribbean Central Bank also conducted the first *DCash* retail transaction. The digital currency initially appeared in four of the eight countries belonging to the Eastern Caribbean Currency Union (ECCU): Antigua and Bermuda, Grenada, Saint Lucia and Saint Kitts and Nevis (Eastern Caribbean Central Bank, 2023; Cyfrowe pieniądze, 2022). In October 2021, the first African CBDC, called *eNaira*, was issued in Nigeria, the only one country so far, which has maintained the same value as the parallel fiat currency (*naira*). This project aims to increase the degree of financial inclusion from 64 to 95%, support economic growth, but also facilitate remittances, stimulate cross-border trade and allow easier payment of social benefits (enaira, 2023). On December 31, 2021, the Central Bank of Jamaica also announced the successful completion of the trial period of the Jamaican Digital Exchange (*JAM-DEX*) project. In May 2022, it informed about its gradual launch. The main motivation behind the development of CBDC in Jamaica was to reduce the cost of storing and handling cash. It is expected that the issuance of digital money will save about USD 7 million per year, which Jamaica currently spends on exchanging, storing and handling cash (Bank of Jamaica, 2023).

Among the project work on the implementation of central bank digital currency developed by the largest economies in the world, the most advanced at the moment is the Chinese digital yuan project (*e-CNY*, *e-yuan*). China is not only a pioneer in the CDBC market, but also the reason for the rest of the world to accelerate work on it. In 2020, the first pilot project was carried out in four Chinese cities, under which randomly selected citizens were given a pool of digital yuan. Then, the project was extended to other cities and provinces and improved with new functionalities of the digital currency. It was also possible to make payments of taxes, stamp duties and social security through CBDC. According to the assumption of the People's Bank of China, the digital yuan will be fully controlled money, with a specific expiration date. However, this allows the government to monitor every financial transaction and exclude the purchase of certain goods or services. What is more, the expiration date means that after its expiry, unused digital money ceases to exist. The steps taken by this country are intended, on the one hand, to achieve the advantage of the first player in this field in the world, and on the other, to secure the role of the state currency in the era of rapid development of stablecoins and other private payment systems. It is also about reducing money laundering, gambling, corruption and terrorist financing, as well as improving the efficiency of financial transactions. The main objective of accelerating

work on the issue of CBDC in China was also to stimulate consumption and stabilize the economy after successive waves of the COVID-19 pandemic (Srinivasan, 2022; People's Bank of China, 2021).

Also Sweden, France, Japan, Turkey, Switzerland, Saudi Arabia and Thailand have prototypes of the first edition of the CBDC, or are at an advanced stage of projects towards the implementation of this solution. Research on central bank digital currency are also conducted by the European Central Bank, which at the moment envisages a possible launch in 2025–2026 (Ferrer, 2022). It declares that the digital euro (*e-euro*) would have the same status as banknotes, only in a different form – electronic record. It would also be issued by the Eurosystem (thus, the ECB and the national central banks of the euro area countries) and available to all citizens and businesses. Therefore, it would be an additional form of money that would increase the choice of payment methods and facilitate their execution, and thus improve availability of payment services and help counteract financial exclusion (ECB, 2022). However, payments with the new e-euro currency would not be anonymous. There might be also a limit to the maximum amount of funds that can be stored in one account. The National Bank of Poland, observing the actions of the ECB, as well as many other central banks in the world, also undertook work on the digital zloty. However, it has not yet provided details of its potential issuance (NBP, 2021).

The United States remains slightly behind in the context of central bank digital currency issuance. This is due to the fact that the US dollar remains the world's main reserve currency and the Federal Reserve System wants to avoid sudden moves that could undermine its position. However, work is being carried out there to examine risks and advantages of CBDC emission. In January 2022, the FED published a long-awaited report on the possibility of issuing CBDC, but it did not specifically commit to the implementation of a digital currency. However, the report highlights the many potential benefits of CBDC and urges Congress and the general public to engage with this important issue (Federal Reserve System, 2022).

In turn, Venezuela, a country that has been experiencing an economic crisis boosted by hyperinflation since 2013, decided to issue digital money in response to international sanctions, imposed due to the deteriorating state of democracy, the rule of law and human rights. These sanctions meant that funds and economic resources of individuals and companies associated with the ruling regime were frozen, which led to complete economic isolation of Venezuela from the outside world and deepening of the internal crisis. Therefore, in August 2018, the government of President Maduro decided to implement digital money (*e-Petro*, *PTR*) guaranteed by the government, secured by natural resources (including oil, gold, iron and diamonds). However, the issue of e-Petro – digital currency based on a fiat currency (Bolivar Soberano) did not bring the intended effect. Then, in 2021, the central bank of Venezuela announced a new stage – implementation of the *digital bolivar*, which aims to support the modernization of the financial system, protect the currency from the pressure of foreign sanctions and reduce transaction costs (Margulies, 2021).

Discussions and conclusions

Taking into account central banks' involvement in the CBDC implementation and their acceptance by the mainstream, it seems that its introduction is almost inevitable. On the other hand, the multi-threaded nature of the central bank digital currency concept causes that analytical work and issue plans may continue for many years. Implementation of CBDC has serious consequences for the functioning of a banking system, financial stability, monetary policy, as well as the whole payment system, that is why central banks face many dilemmas of choosing both the type and model of CBDC to maximize benefits and minimize possible disruptions. Therefore, before the widespread issuance of a digital currency is possible, comprehensive and balanced theoretical as well as pilot studies are needed to assess challenges associated with the issuance of CBDC and its potential compared to traditional currency.

Central bank digital currency is a part of the dynamically changing payment ecosystem. The global adoption of CBDC will effectively accelerate the development of the crypto industry's growth and result in financial inclusion, especially in unbanked countries where many people do not have a bank account. However, it must be secure from the technological side – protected against fraud, cyber threats and abuse, ensure privacy and security of funds, in order to function appropriately. This will undoubtedly require implementation of a specific legal framework that would ensure the proper functioning of CBDC. It is also worth emphasizing that from the central bank point of view, digital currency will facilitate the effective conduct of monetary policy and ensure/maintain financial stability. However, everything depends on the assumptions and solutions that will be adopted at the design stage of a given digital currency. Therefore, the current knowledge does not fully exhaust doubts and questions that arise taking into account the conditions of a given country. More studies are needed to fully understand the full range of effects and quantify financial stability implications of CBDC.

The conducted empirical research has indicated that a degree of involvement of individual central banks in the world is different. Pilot projects and tests undoubtedly play an important role, which allows to examine effectiveness and implementation of the CBDC goals, technical capabilities and infrastructure, as well as community's attitude towards the use of digital currency. Experimental work should cover both the private and institutional sectors to explore the pros and cons of different CBDC models. Despite the fact that many countries emphasize opportunities and benefits of the digital currency, they also point to various barriers and risks that weaken their motivation for the practical implementation of CBDC in their economies. However, benefits and barriers should be considered in parallel. If a central bank is to provide the public digital currency, which is also a legal tender, its possession should certainly not be subject to quantity ceilings and deposit claims against commercial banks should be fully redeemable. Moreover, if CBDC is to improve the resilience of the payment system, most users should have a certain amount of digital currency at all times. While, if CBDC is to increase diversity and sovereignty of payment

systems, people should actively use it to settle their daily transactions. However, it may happen that under Gresham's Law, demand-limiting mechanisms for CBDC will undermine its widespread use as a medium of exchange in everyday transactions, because people will accumulate their credit risk free CBDC and instead spend risky bank deposits. It is, therefore, unlikely that a CBDC will promote diversity and sovereignty of payment systems. All these barriers and limitations tend to positively verify the adopted research hypothesis, stating that despite growing involvement of central banks in the work for the issue of CBDC, its barriers and limitations are large enough to inhibit practical implementation. The results showed that such barriers as: a fixed expiry date, lack of anonymity and full control of a central bank over its use may significantly limit further monetary authorities' works on its implementation.

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