

**M A S A R Y K  
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FACULTY OF ECONOMICS AND ADMINISTRATION

# **Central Bank Digital Currency: risks and efficiency**

Bachelor thesis

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## **Abstract**

The aim of this bachelor thesis is to analyze and evaluate the possible benefits and risks of central bank digital currency (CBDC) implementation. CBDC is a very up to date and innovative topic, which is gaining more and more interest not only from the central banks but also from the broader public. Considering our findings based on a comparison of academic literature and approaches to the CBDC from different countries, we believe that if the central banks do not underestimate the risks, CBDC can serve as a powerful and influential monetary and payment tool.

## Declaration of Authorship

Prohlašuji, že jsem bakalářskou práci na téma Central Bank Digital Currency: risks and efficiency vypracovala pod vedením Olega Deeva, Ph.D. a uvedla v ní všechny použité literární a jiné odborné zdroje v souladu s právními předpisy, vnitřními předpisy Masarykovy univerzity a vnitřními akty řízení Masarykovy univerzity a Ekonomicko-správní fakulty MU.

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.....  
Romana Dršková

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## Table of Contents

<b>List of Figures</b>	<b>13</b>
<b>List of Tables</b>	<b>14</b>
<b>Glossary</b>	<b>15</b>
<b>Introduction</b>	<b>17</b>
<b>1 Theoretical foundations</b>	<b>19</b>
1.1 Historical background and motivation .....	19
1.2 Definition of CBDC.....	20
1.3 Possible designs of CBDC.....	21
<b>2 Possible benefits and risks of CBDC</b>	<b>26</b>
2.1 Benefits of CBDC implementation.....	26
2.2 Risks of CBDC implementation.....	32
<b>3 Comparison of CBDC's research and development across countries</b>	<b>37</b>
3.1 Launched CBDCs .....	38
3.2 Pilot Project Phase CBDCs.....	46
3.3 Research and Development Phase CBDCs .....	51
<b>4 Evaluation of risks and benefits of CBDC</b>	<b>56</b>
<b>Conclusion</b>	<b>60</b>
<b>References</b>	<b>62</b>

## List of Figures

Figure 1: Retail CBDC architectures and central bank-private sector cooperation .....	23
Figure 2: Frictions in current correspondent banking arrangements...	29
Figure 3 - Model 1: multi-CBDC arrangements based on compatible CBDC systems.....	30
Figure 4 - Model 2: multi-CBDC arrangements based on linking multiple CBDC systems.....	31
Figure 5 - Model 3: multi-CBDC arrangements based on a single multi-currency system .....	32
Figure 6: Respondents to the 2020 survey.....	37
Figure 7: Respondents to the 2021 survey.....	38
Figure 8: Digital Sand Dollar Eco-System.....	41

## List of Tables

Table 1: Tiered KYC Requirements for Sand Dollar Accounts .....	42
Table 2: Costs and benefits of the Bahamian Digital Sand Dollar implementation .....	42
Table 3: Benefits of the DCash:.....	43
Table 4: The eNaira Consumer Wallet Tier Structure:.....	46
Table 5: Key benefits of the e-CNY to consumers .....	50
Table 6: Core principles .....	52
Table 7: Scenario-specific requirements.....	53
Table 8: General requirements .....	54
Table 9: Summarized comparison of CBDC benefits and risks of the above-analyzed countries.....	57

## Glossary

AML	– Anti-money laundering
BIS	– Bank for International Settlements
CBDC	– Central Bank Digital Currency
CBDCs	– Central Bank Digital Currencies
CBOB	– Central Bank of The Bahamas
CBN	– Central Bank of Nigeria
CEPR	– Centre for Economic Policy Research
CPMI	– Committee on Payments and Market Infrastructures
ECB	– European Central Bank
ECCB	– Eastern Caribbean Central Bank
ECCU	– Eastern Caribbean Central Union
EMEs	– Emerging Market Economies
FED	– Federal Reserve System
ID	– Identification Card
IMF	– International Monetary Fund
KYC	– Know Your Customer
PBOC	– People’s Bank of China
PSMI	– Payments System Modernisation Initiative
PSP	– Payment System Provider
UK	– United Kingdom of Great Britain and Northern Ireland
USA	– United States of America
WB	– World Bank

## Introduction

The economy and finance are getting more and more digital. Fintech companies, cryptocurrencies, stablecoins, possibility to pay via mobile phone, all contribute to this trend. In the last years the use of cash has been declining, with the pandemic accelerating the downtrend as people prefer contactless forms of payments.

The idea that central banks would issue digital forms of money for general use is a natural progression from the issuance of physical cash. Additionally, banks have had access to digital forms of central bank money for several decades in the wholesale payment system. However, in recent years there can be seen an increased interest in a central bank digital currency (CBDC) that would be issued and regulated directly by the central bank and available to the general public (Auer et al., 2021b).

We believe that the topic of CBDC is very up to date and the way the central bank design and issue CBDC will have a huge impact on the future of payments. Therefore, the aim of this bachelor thesis is to analyze and evaluate the possible benefits and risks of CBDC implementation.

In the first chapter, we present a comprehensive literature review of the current state of central bank digital currency around the world. We begin with the description of the theoretical foundations of CBDC, what is the history and motivation behind its creation. We present several definitions of the CBDC from different authors as one generally accepted definition does not exist yet. We also describe the possible technology and design solutions how CBDC could look like.

In the second chapter we define the most common benefits and risks of CBDC. The benefits include financial inclusion, reduced reliance on payment service providers, better detection of illegal activities, additional policy instrument, more efficient retail payments and faster, cheaper, and more resilient cross-border payments. Disruption of financial stability such as financial disintermediation and bank runs belong to the potential risks of the CBDC. Another significant risk of CBDC is the concern about data privacy and the threat of cyber-attacks.

The third chapter focuses on comparing the CBDC research and implementation in the chosen countries with the focus on their approach to the potential benefits and risks of the CBDC. We have divided this chapter into three sections according to the level of their CBDC work. For the purpose of this thesis the countries we have chosen five countries and two

currency unions. The states are The Bahamas, Nigeria, Sweden, China, and the United States of America and the two chosen currency union include the Eurozone and the Eastern Caribbean Currency union.

In fourth chapter we provide an overall summary of the benefits and risks of the chosen countries presented in the previous chapter and we evaluate and analyze the results.

# 1 Theoretical foundations

## 1.1 Historical background and motivation

Payment systems, especially money, are evolving rapidly. Developments in information technology and digital networks contribute significantly to this transformation (Agur, Ari, Dell’Ariccia, 2021). The idea of extending central bank money in digital form to the public is not entirely new. Tobin (1987) proposed the idea of “*deposited currency*”, or “*a medium with the convenience of deposits and the safety of currency*”, to enhance payments and reduce the reliance on deposit insurance.

Motivations for retail CBDC research and development are driven by global trends and country-specific circumstances. These motivations include promoting financial integration, improving transactions efficiency and security, and decreasing the cost of cross-border payments (MAS and Bank of Canada, 2019).

Financial integration and inclusion are one of the most important motivations, especially in the emerging market economies (EMEs), where the banking and financial sector is underdeveloped, and many people do not have access to the traditional banking services. The cross-border payments present a crucial part of the international finance sector and the way they function today is rather ineffective, slow, and expensive. The issuance of CBDC might help with these problems, therefore, central banks are exploring whether and how they should adapt.

An increasing number of central banks and international financial organizations have been actively exploring the possibilities of CBDC and released CBDC research reports. A 2021 BIS survey of central banks found that 86% are actively researching the potential for CBDCs, 60% were experimenting with the technology and 14% were deploying pilot projects.

The first publicly announced work on retail CBDCs was conducted by Sweden’s Riksbank, where the use of cash has greatly declined. Another advanced CBDC project is the electronic Chinese yuan (e-CNY) of the People’s Bank of China. Since 2020, they piloted CBDC in several cities in China. Further research and implementation of their CBDC project have taken place during the Winter Olympics in Beijing in February 2022.

Auer et al. (2021b) from the Bank for International Settlements state four developments that contributed to and accelerated the interest in the research of CBDCs. The first one was the increased interest in cryptocurrencies, namely Bitcoin. Cryptocurrencies are considered speculative assets rather than money because they are extremely volatile. They are often used for illicit activities such as money laundering (Foley et al., 2019). A second development is the creation of private sector-issued stablecoins. In comparison to cryptocurrencies, stablecoins should maintain a stable value through their backing of assets. However, they can still affect the monetary system's liquidity and are considered to be only an extension of the traditional monetary system. Thirdly, big tech companies entered into payments. They collect and process a huge volume of personal data, which introduces new challenges for central banks. These include the power of companies to have exclusive use of personal data and secondly, the effects on data privacy and governance. The final development is the global Covid-19 pandemic. The disruption by the Covid-19 pandemic forced countries to embrace digitalization and emerge with cutting-edge technologies and accelerated the central banks' interest in exploring CBDC (Lee, Yan, Wang, 2021).

## 1.2 Definition of CBDC

Central Bank Digital Currency (CBDC) is considered to become a new form of money in the digital era. One specific globally accepted definition of CBDC does not exist yet. However, there are several approaches to its definition. Central banks have different CBDC orientations, and they define the business, technology, and structure differently.

CBDC should have four basic functions of a currency: *“medium of exchange, store of value, unit of account and standard of deferred payments”* (Lee, Yan, Wang, 2021).

International Monetary Fund (Kiff et al., 2020) defines CBDC as *“a digital representation of a sovereign currency issued by and as a liability of a jurisdiction's central bank or the monetary authority”*.

Bank of England (Kumhof and Noone, 2018) defines CBDC as *“an electronic central bank money which is more widely accessible than reserves, is interest-bearing, has functionality for retail transactions, has a different operational structure as compared to other forms of money”*.



According to Bank for International Settlements (Auer, Cornelli, and Frost, 2020) CBDC is *“a digital form of central bank money that is different from balances in traditional reserves or settlement accounts”*.

European Central Bank (Bindseil, 2020) presents CBDC as *“a form of central bank money which is managed through electronic means and is accessible to the larger public”*.

CBDC may have some similarities with cryptocurrencies or stablecoins, however, they are not interchangeable, and their purpose is different. CBDC would be centralized and regulated directly by the central banks. Cryptocurrencies can be considered as a digital medium of exchange and a decentralized payment system based on cryptography (Luther and White, 2014). ECB defined a crypto-asset as *“a new type of asset recorded in digital form and enabled by the use of cryptography that is not and does not represent a financial claim on, or a liability of, any identifiable entity”*. Stablecoins have also several possible definitions. Bullmann et al. (2019) define stablecoins as *“digital units of value that are not a form of any specific currency but rather, by relying on a set of stabilization tools, try to minimize fluctuations in their price in such currencies”*. The main difference between stablecoins and cryptocurrencies is that stablecoins are designed to be less volatile and they are meant to hold a stable value.

Cryptocurrencies, stablecoins and CBDC have in common that they would all represent a digital form of asset. However, there are many differences. CBDC would be a direct liability to the central bank, it is aimed to be widely accessible and acceptable, used primarily for payments and not for investments. CBDC will have also stable value as it will be pegged to the national currency of individual countries or monetary union. Finally, CBDC can be considered to be less risky as it would be regulated directly by the central banks, therefore, CBDC will be subject to stricter requirements.

### 1.3 Possible designs of CBDC

CBDC should be easily accessible and widely acceptable. There are several possibilities for how it could be designed.

The business design distinguishes between wholesale CBDC and retail CBDC. Wholesale use design is more limited, as it could be used only between financial institutions. Retail CBDC would be a central bank

liability, a form of “digital cash” that would be available to all (Auer et al., 2021b).

For ledger design, CBDC can be divided into token-based and account-based. Token-based CBDC refers to the use of tokens for transactions between digital wallets through centralized or decentralized settlement systems. The advantage of the token-based form is its anonymity and the possibility for offline transactions. Account-based CBDC on the other hand is traded by opening an account either directly in the central bank or the commercial bank (Lee, Yan, Wang, 2021).

There are two possible approaches to CBDC when it comes to interest rates of CBDC. The first approach is non-interest-bearing CBDC. This type of CBDC would mostly resemble cash, its nominal value would be fixed and would not change.

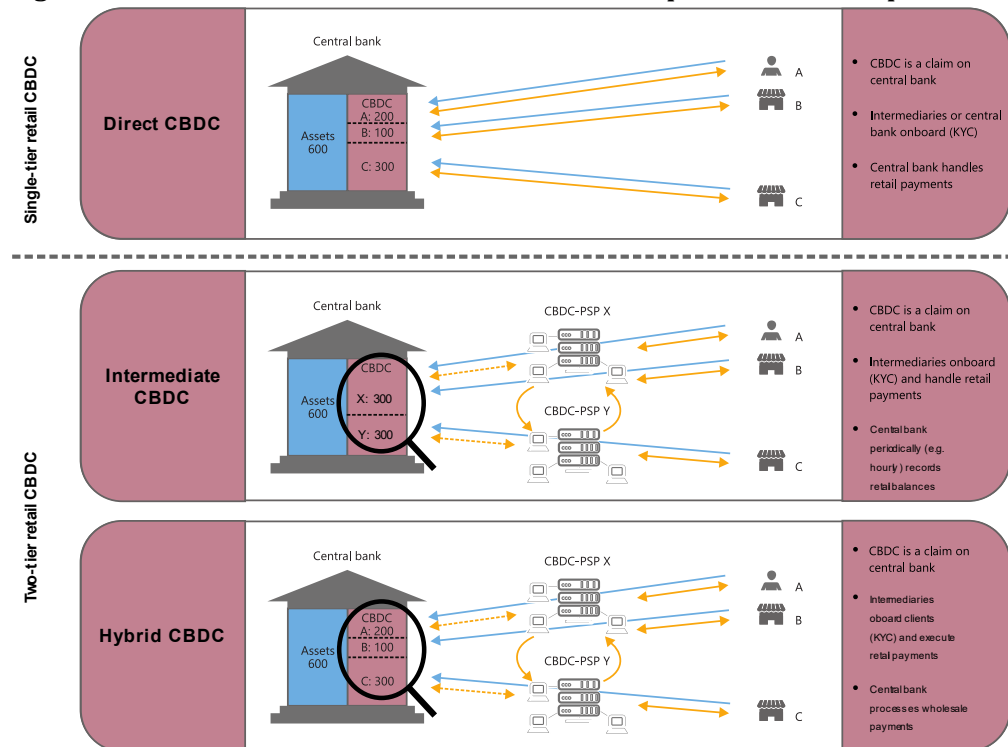
The second approach is an interest-bearing CBDC. This type of CBDC would more resemble bank deposits, the interest rate could be set either positive or negative depending on the circumstances and goals of central banks. Interest-bearing CBDC can be used as a direct monetary policy tool and can give the central banks more direct control of the money supply (Lee, Yan, Wang, 2021). Kumhof and Noone (2021) state that a variable interest rate of CBDC is important for two reasons, first during normal times, when it can be used as an additional policy tool to manage financial market conditions and affect aggregate demand, and second during crises, where the interest rate can be lowered relative to the policy rate, if necessary to negative levels, to discourage bank runs.

The optimal operating model is crucial for the function of the CBDC, especially for its retail form. Auer and Böhme (2021) discuss three types of operating models for retail CBDC, which are depicted in Figure 1. In all three architectures, the central bank is the only party issuing and redeeming CBDC.

In the single-tier or direct operating model, the CBDC is a direct claim on the central bank, which also handles all payments in real-time and thus keeps a record of all retail holdings (Auer and Böhme, 2021). This model resembles accounts at commercial banks, except here the accounts would be held directly with the central bank. This model gives central banks more control over the product design and implementation process. However, there are several concerns associated with this single-tier mode, namely the fact that the central bank would have to substitute for many activities the private sector used to be responsible for. That is not only expensive and technically difficult, but it could also lead to the

disintermediation of the private banking sector (Auer and Böhme, 2021). Therefore, this single-tier model might be more appropriate for low-income countries with a well-resourced central bank on hand but with an underdeveloped financial sector on the other hand. Due to the lack of other financial institutions, it might be difficult to distribute and provide payment services, therefore, CBDC issued directly by the CBDC could be a good solution.

**Figure 1: Retail CBDC architectures and central bank-private sector cooperation**



Source: Auer and Böhme (2021)

The hybrid CBDC architecture combines the credibility of a direct claim on the central bank with the convenience of the private sector. CBDC is not on payment service providers (PSP) balance sheets, therefore, user holdings are not exposed to claims by PSP creditors in case of PSP insolvency. However, if a PSP fails, the central bank must be able to honour claims and, ideally, resume payments for the failing PSP's customers without much delay. This capability requires sufficient information about retail accounts to be available to the central bank (Auer and Böhme, 2021).

The third type is the intermediated CBDC architecture, in which the central bank record only wholesale balances of the payment system providers. Central banks might prefer this type due to its privacy and data security concerns. However, the disadvantage of this CBDC architecture is that the central bank needs to honour claims that it has no record of and must rely on the integrity and availability of the PSP's records (Auer and Böhme, 2021).

Auer and Böhme (2021) conclude that both hybrid and intermediated CBDC architectures would have better financial resilience than fully backed payment accounts. They could also be easier to operate for the central bank than the direct CBDC.

Agur, Ari and Dell'Ariccia (2021) study the optimal design of a CBDC. Their model assumes that agents sort into cash, CBDC and bank deposits according to their preferences over anonymity and security.

Their starting point is an economy with banks, firms, and households. They suppose that both banks and firms engage in perfect competition. They expect the households to have different preferences between cash and deposits as cash provides anonymity in transactions, however, bank deposits are more secure. CBDC can take any point in between, depending on its design.

They state that considering the design of the CBDC, households optimally sort into types of money based on three considerations: *"firstly, their heterogeneous preferences, secondly, network effects, which derive from the relation between the convenience of using a payment instrument and the number of its users, and thirdly, the interest rates offered on deposits and possibly on CBDC"*.

Their results show that the welfare optimal CBDC design hinges on whether the CBDC is interest-bearing, and whether network effects matter. Their modelling of network effects is based on the work of Katz and Shapiro (1985) with the difference of introducing a completely new payment instrument. Katz and Shapiro (1985) describe the source of positive consumption externalities as the *"utility that a user derives from consumption of goods which increases with the number of other agents consuming the (same) good"*. Agur, Ari and Dell'Ariccia (2021) argue that as long as network effects do not constrain policy, the CBDC interest rate is best kept at zero because it brings about price distortions in the households' choice of payment instruments.

However, when network effects pose a threat to the variety of payment instruments, an interest bearing CBDC becomes optimal and helps

the central bank alleviate the central bank's tradeoff. The adjustable CBDC interest rate could be used to ensure that cash remains use.

In the conclusion, Agur, Ari and Dell'Ariccia (2021) argue stress that in an economy where the bank's role is limited, CBDC is best designed in a manner that is as distinct from existing payment instruments as possible. The reason for this is the fact that of the CBDC closely competes with deposits it can causes declines in bank credit and output, while a cash-like CBDC may lead to the disappearance of cash.

## 2 Possible benefits and risks of CBDC

In this chapter, we define and describe the common potential benefits and risks of CBDC. Some of them are present in all possible types and approaches to CBDC, however, some of them are only present in a specific type of CBDC.

### 2.1 Benefits of CBDC implementation

CBDC presents new possibilities and improvements to the current payments system and infrastructure. According to Qian (2019) in comparison with traditional fiat money, CBDC offers unique payment qualities that should be used to the fullest extent.

Wu and Chen (2021) summarize the major reasons for the CBDC phenomenon. These include improving the competitiveness, efficiency, and resilience of payment systems. CBDC can help advance financial digitization and inclusive finance, especially in countries, where citizens have limited access to bank accounts. CBDC can greatly reduce the cost of the monetary base and also realize M0 data recording and tracking, therefore, it can help prevent and control financial risks caused by shadow banking. Due to the digital form of CBDC, it is also more hygienic than banknotes and coins, which is an important feature, especially, during the pandemic.

In this section, we will describe these possible benefits and how they could improve certain current inefficiencies.

#### Financial Inclusiveness

Lee, Yan, and Wang (2021) suggest that a great advantage of CBDC is its inclusiveness because it makes it possible to conduct payments through eWallets without the need for identities, accounts or even an Internet connection. This benefit is particularly important in developing countries where the financial system is underdeveloped, and many citizens do not have bank accounts (Wu and Chen, 2021). This inclusiveness can

also help countries with more precise and accurate measurements of economic activities (Lee, Yan, and Wang, 2021).

### **Reduced reliance on payments service providers**

Today, central banks issue two types of money and provide infrastructure to support a third. They issue physical cash, which is widely accessible and peer-to-peer and central bank reserves, which are electronic and typically only accessible to qualifying financial institutions. The third type of money is private money, principally available through widely accessible and electronic commercial bank deposits. While cash and reserves are a liability of the central bank, commercial bank deposits are not (BIS et al., 2020). As the use of cash declines, the consumers use more private money, and it is more difficult for the central bank to maintain its strong monetary position. Introducing a CBDC, which would be an electronic form of money on one hand, but direct claim to the central bank, on the other hand, could help the central bank to remain the most important monetary authority and become more independent from a third-party service.

### **Detection of illegal activity**

Cash provides complete anonymity in transactions, therefore, it can be easily used for illegal activities such as tax evasion, money laundering and terrorism financing. Even when citizens use alternative forms of payments such as cryptocurrencies, it is difficult to trace these transactions. CBDC could provide managed anonymity and help the central bank to capture the necessary data to easier detect illegal activities (Lee, Yan, and Wang, 2021). Thanks to the possible traceability of the financial transactions, CBDC could contribute to anti-money laundering, counterterrorism financing and anti-tax evasion (Qian, 2019).

### Additional policy instrument

Kumhof and Noone (2021) define CBDC as *“an electronic central bank money that can be accessed more broadly than reserves, potentially has much greater functionality for retail transactions than cash, has a separate operational structure to other forms of central bank money and can be interest bearing.”* Taking into consideration this definition they explore whether CBDC can be used as a second policy tool. This policy tool could have a form of an interest rate rule, where the central bank sets the interest rate on CBDC and allows the quantity to vary or a quantity rule, where the central bank sets the quantity of CBDC supplied and allows the interest rate to vary.

Lee, Yan, and Wang (2021) suggest that interest-bearing CBDC can be used as a direct monetary policy tool and can give the central banks more direct control of the money supply. They argue that in contrast, non-interest-bearing will perform the function of digital public infrastructure to overcome friction in the financial space.

### Efficient retail payments

CBDC offers several advantages with regards to the convenience, efficiency, stability, and accessibility of retail payment. Even though, electronic payments have already been possible for several decades via commercial bank money, offering electronic payments directly in central bank money could have additional advantages (Bindseil, 2019). CBDC applies to various mediums of exchange and payment channels, and therefore is universal and has an extensive presence. Theoretically, CBDC can reach the boundary of a payment network as far as bank deposit currency and electronic currency do (Qian, 2019).

According to Qian, CBDC can address the defects of cash. These defects include firstly the impossibility to reach a negative interest rate, secondly, the usage for tax evasion and illegal activities and thirdly, the costs of storage, issuance, and processing of cash. Qian further states that these problems could disappear with the issuance of CBDC because *“custodian charge can be levied on CBDC, which produces the same effect as a negative interest rate”*, secondly, *“the traceability of CBDC will contribute to anti-money laundering, counterterrorism financing and anti-tax*



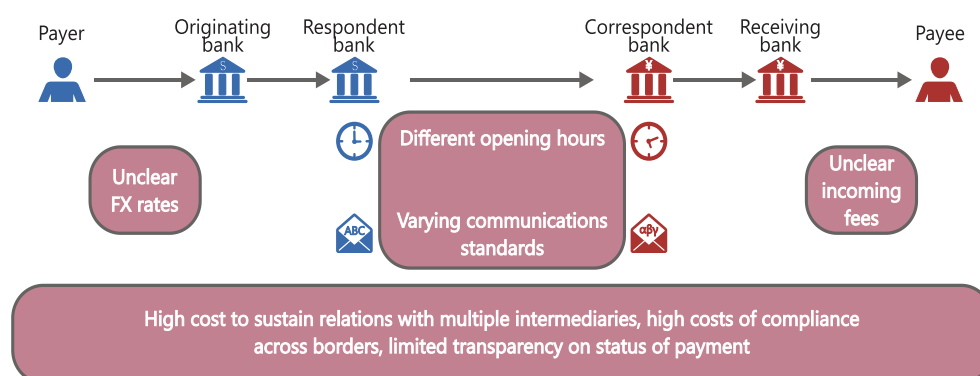
*evasion” and thirdly, “the costs of CBDC issuance and trading will be significantly lower, because coinage, circulation, and storage are digitized.”*

Lee, Yan, and Wang (2021) also suggest that CBDC can reduce the high cost of traditional paper money issuance and circulation and save considerable expenditure on labour and materials.

## Efficiency in cross-border payments

Cross-border payments are an important part of the globalized economy. They are often criticized for their high cost, low speed, limited access, and insufficient transparency. Figure 1 depicts current frictions in cross-border payments. CBDC could simplify and enhance the performance of cross-border payments. One way could be through interoperating CBDC and forming so-called multi-CBDC arrangements. The potential benefits of the multi-CBDC arrangements would be especially relevant for the emerging market with underdeveloped banking systems (Auer, Haene and Holden, 2021).

**Figure 2: Frictions in current correspondent banking arrangements**



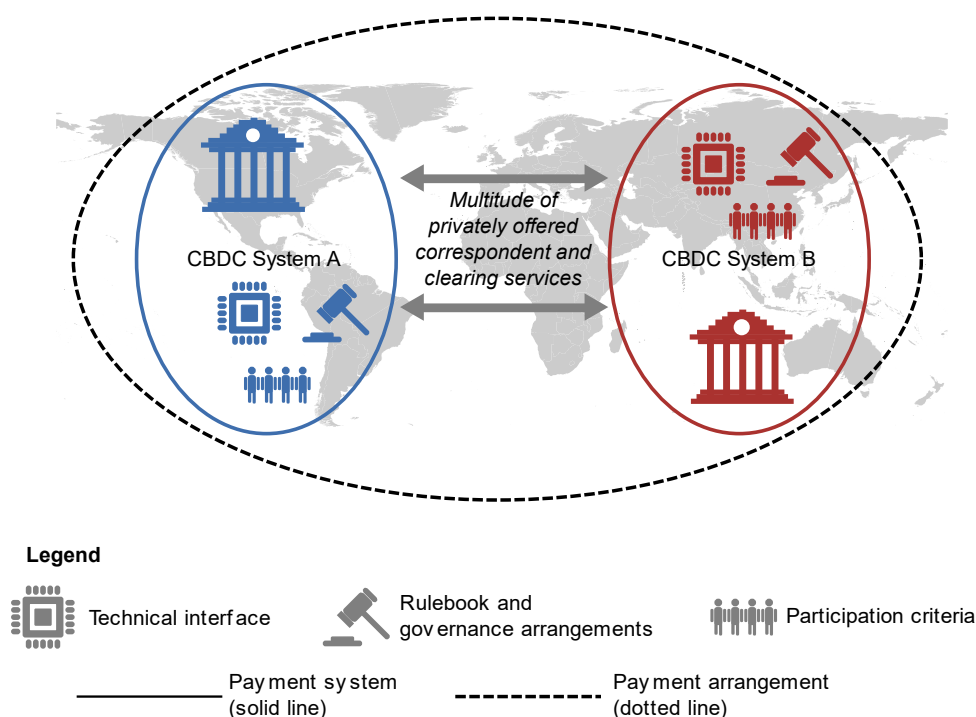
Source: Auer, Haene and Holden (2021)

In comparison to improving the existing forms of payments infrastructure, CBDC presents an opportunity, to begin with, a “clean slate”. To the advantage of this opportunity, central banks should consider the international dimension while investigating the domestic CBDC and commit to interoperability, consistent standards, and coordination of CBDC designs (BIS, CPMI, IMF, and WB, 2021).

Different levels of payment system interoperability can be used to group potential multi-CBDC arrangements. The three models designed by Auer, Haene and Holden (2021), depicted in Figures 3, 4 and 5 present conceptual illustrations of how these arrangements could work. All three models can improve the problem of mismatch of opening times across time zones because CBDC can be open 24/7 and CBDCs in all models could also tackle the problem of limited transparency on the status of payment by being able to settle instantly, reducing the need for status updates.

Model 1 resembles traditional cross-border payment arrangements. Transfers between CBDCs are offered by a multitude of competing private companies, which benefit from compatibility measures and broadly similar participation requirements. Each CBDC system determines its separate rulebook and governance, as well as participation criteria, and infrastructure (Auer, Haene and Holden, 2021).

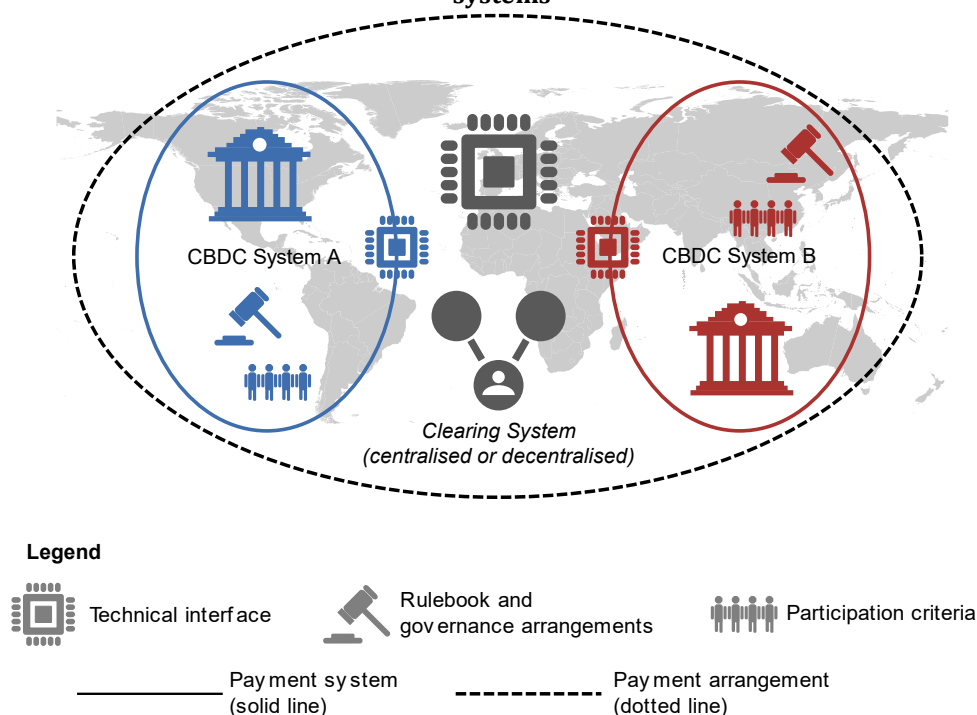
**Figure 3 - Model 1: multi-CBDC arrangements based on compatible CBDC systems**



Source: Auer, Haene and Holden (2021)

Model 2 incorporates additional interlinkages. The interlinking systems allow some functionalities that would not be possible with a purely informal arrangement. However, linking a payment system is a very complex task and requires compatible measures. The required arrangements can take two forms, a shared technical interface, or a common clearing mechanism. In the case of CBDC, this could be achieved through decentralised, reciprocal accounts or a more centralised common settlement agent or system. Each CBDC system would still determine its separate rulebook and governance, as well as participation criteria, and infrastructure (Auer, Haene and Holden, 2021).

**Figure 4 - Model 2: multi-CBDC arrangements based on linking multiple CBDC systems**



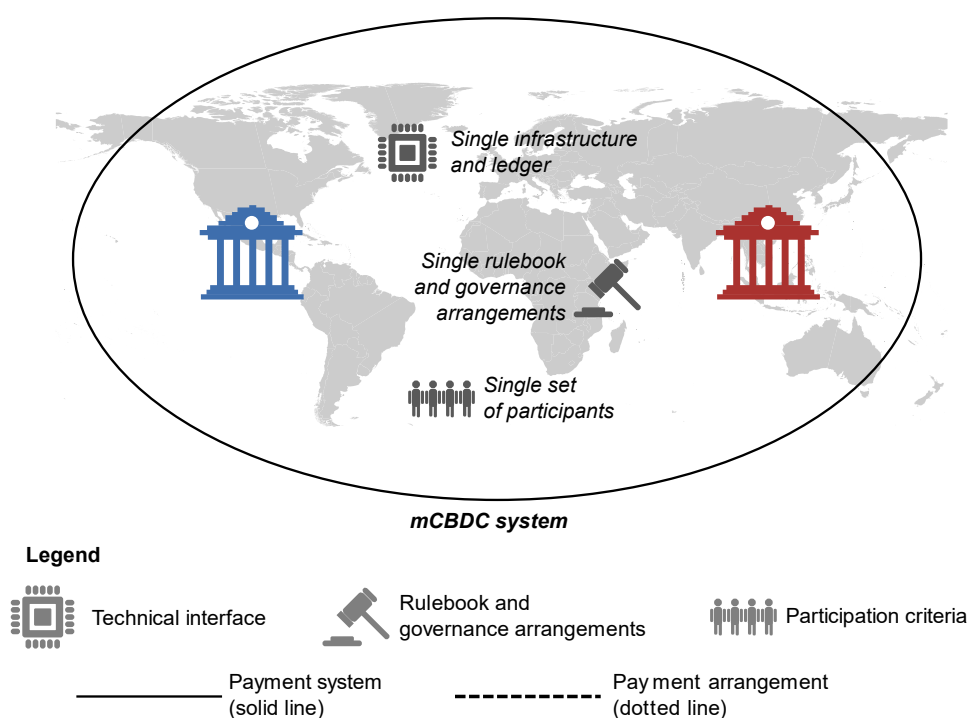
*Source: Auer, Haene and Holden (2021)*

Model 3 implies cooperation of a higher magnitude among central banks. It includes creating a single system with multiple CBDCs that have a single rulebook, a single set of participation requirements and one supporting infrastructure. This deep integration would allow for more operational functionality and efficiency on one hand, but it would lead to

increased governance and control hurdles on the other hand. It opens possibilities for new technologies, e.g., CBDCs could be issued into a common distributed ledger. Creating one single system brings significant challenges as central banks will need to relinquish some of their system control and monitoring functions to an operator (Auer, Haene and Holden, 2021).

The eventual international adoption of CBDCs is likely to proceed at different speeds in different jurisdictions, therefore, central banks must focus on interoperability with legacy payment arrangements (BIS, CPMI, IMF and WB, 2021).

**Figure 5 - Model 3: multi-CBDC arrangements based on a single multi-currency system**



Source: Auer, Haene and Holden (2021)

## 2.2 Risks of CBDC implementation

CBDC presents great opportunities and possibilities to the current financial and payments system, however, it entails also certain risks that

cannot be ignored. In this section, we define the most common potential risks that CBDC presents.

CBDC may in the long term create a new price-based monetary policy instrument, however, there will likely be uncertainty in existing monetary policy instruments and transmission mechanisms in the short term (Wu and Chen, 2021). The implementation can disrupt the financial stability, having an impact namely on financial disintermediation and bank runs, which will be discussed in the next sections.

Fernandez-Villaverde et al. (2021b) present an interesting contribution to the possible risk of CBDC as they show an impossibility result which they named the “CBDC trilemma”. In their research, they found that *“the central bank can never attain price stability, monetary trust (absence of central bank runs) and the socially optimal allocation at the same time”*.

Fernandez-Villaverde et al. (2021b) further argue that a central bank that wishes to simultaneously achieve a socially efficient solution, price stability, and financial stability will see its desires frustrated. They have shown that a central bank can only realize two of these three goals at a time.

## Financial disintermediation

If households substitute commercial bank deposits with CBDC, then this would imply a funding loss for commercial banks and could lead to “disintermediation” of the banking sector. This will be a problem mostly for sight deposits with low remuneration, where clients would prefer CBDC. To avoid big losses of clients, commercial banks will have to offer better conditions on their deposits, however, this would imply higher costs for banks and possible loss of commercial bank “seigniorage” (Bindseil, 2019).

Bindseil (2019) also argues that on one side the central bank would benefit from an unfair competitive advantage in deposit collection and gain extra power and market share. On the other hand, central banks would have competitive disadvantages in credit provision, which they could ignore, but that would lead to inefficiency, conflicts of interest and financial losses that eventually the taxpayer would have to bear.

BIS et al. (2020) also state that CBDC brings the possible risk of dis-intermediating banks. If banks begin to lose deposits to CBDC over time they may come to rely more on wholesale funding, and possibly restrict credit supply in the economy with potential impacts on economic growth. BIS et al. (2020) therefore stress that the central bank should have robust means to mitigate any risks to financial stability before any CBDC is issued.

### Bank runs

Under the term bank run, we can understand *“a threat of a sudden and significant number of deposit withdrawals taking place in a short time frame, which could lead to a shortfall in liquidity deriving into insolvency”*. (Sanchez-Roger et al., 2018). When we talk about bank runs concerning CBDC we can use the concept of a digital bank run, which can be understood as a *“bank run that takes place in a commercial bank where depositors (retail and wholesale) withdraw their deposits and place them in digital currencies”*. (Sanchez-Roger and Puyol-Antón, 2021) In discussions of the benefits and risks of CBDC, concerns about the vulnerability of the banking system to such digital bank runs are very common (Kumhof and Noone, 2021).

Lee, Yan, and Wang (2021) argue that if the public can obtain an unlimited amount of CBDC, the demand for deposits or reserves of commercial banks will be reduced. This will cause a liquidity shortage for the banks and can trigger bank runs in case of market panic. Wu and Chen (2019) also warn that if savers lose trust in the commercial banks and if the CBDC offers a higher credit rating, they will select CBDC over commercial banks deposits, possibly creating a wide-scale run on bank savings.

Fernandez-Villaverde et al. (2020a) research the risk of bank runs caused by CBDC by building a model based on the classic model by Diamond and Dybvig (1983). The Diamond-Dybvig model is an influential model of bank runs. It proposes that banks create liquid claims against illiquid assets, and it shows that pure panic can cause a bank run. The basic structure of the Diamond-Dybvig model has become a platform on which hundreds of other banking-related models have been built. Fernandez-Villaverde et al. augmented the traditional model with the presence of a central bank. They conclude that provided competition with

commercial banks is allowed and if the consumers do not panic, the set of allocations achieved with private financial intermediation can also be achieved with a CBDC. However, they warn that if the competition with commercial banks is violated, the central bank needs to make its decisions carefully in order not to havoc with maturity transformation.

Bitter (2020) found that a CBDC strains the banking sector in normal times by reducing deposits and net worth. Yet, contrary to prevailing concerns, CBDC improves financial stability in times of crisis by impeding the emergence of bank runs.

According to Kumhof and Noone (2021), when the economy experiences a sudden loss of confidence in the banking sector, it can result in a large-scale attempt to switch from holding bank deposits to holding CBDC. The problem arises namely if the size of the switches from bank deposits to CBDCs is very large and the switch is not orderly but instead takes place in an environment of a financial market panic.

In their CBDC research, Kumhof and Noone (2021) define four conservative core principles that CBDC should fulfil. CBDC pays an adjustable interest rate, CBDC and reserves are distinct and not guaranteed to be directly convertible into each other at the central bank, there is no guaranteed convertibility of bank deposits into CBDC at commercial banks and the central bank guarantees to issue CBDC only against eligible securities.

They argue that if their core design principles are followed, then bank runs are as feasible in a world without CBDC as in a world with CBDC. On the opposite, they suggest that thanks to the advantages of CBDC in limiting bank risk-taking and in facilitating bank resolution, these events may even be less likely with CBDC.

In conclusion, Kumhof and Noone (2021) state that bank runs can never be completely ruled out under fractional reserve banking, the best that can be achieved is to reduce the probability of their occurrence to a minimum.

### **Concerns about data privacy, the threat of cyber attacks**

Concerning data privacy, the issuance of a CBDC can be considered a form of benefit because central banks have no incentive to use private transaction data and they can leave these untouched in a way that commercial banks or digital platforms could not (Agur, Ari, Dell’Ariccia,

2021). Survey evidence shows that users place greater trust in public authorities and traditional financial institutions, when it comes to safeguarding their personal data, than they do in new players such as big techs (Armantier et al., 2021). Moreover, application programming interfaces (APIs) in a CBDC system can constrict data exchange to only the necessary information for any given transaction and give users greater control over the data that they generate (BIS, 2021).

While CBDC may offer advantages regarding data privacy, there are also certain risks which have to be considered. If the CBDC is designed fully anonymous, similar to cash, this could have severe drawbacks for the payment system integrity, allowing for illicit transactions, money laundering and terrorism financing (Auer et al., 2021b). Wang (2021) shows that a fully cash-like CBDC design could also increase tax evasion. If on the other hand CBDC is designed to maintain a full record of transactions attached to users' identities, this presents new challenges for cyber security, as the central banks can become an attractive target for data hackers (Auer et al., 2021b). Similarly, according to Lee, Yan, and Wang (2021), the technologies that are necessary for CBDC functionalities are still in the development stage and the private user data could be subject to cybersecurity risk.

Keister and Monnet (2021) also state three concerns regarding data privacy. Firstly, they argue that the most obvious concern is that a concentration of data creates digital monopolies, which may lead to a lack of innovation and higher prices. They suggest that platforms with the most precise information can price discriminate more efficiently or even discourage purchases on competing platforms. Secondly, the algorithms used by platforms create externalities that lead consumers to underinvest in privacy. They state that this concern tends to be less obvious, however, not less important. They argue that *"when everyone undervalues their own privacy, we all provide too much information to the platforms we use, which exacerbates the data monopoly problem."* The third doubt arises in situations where the private value of information is higher than the social value because this can cause platforms to overinvest in accumulating information about their customers.

In conclusion, CBDC presents many significant benefits, which can help with solving current problems in the financial sector, on the other hand, it is important that central bank remain cautious in order not to create more risks and problems than they are able to solve.



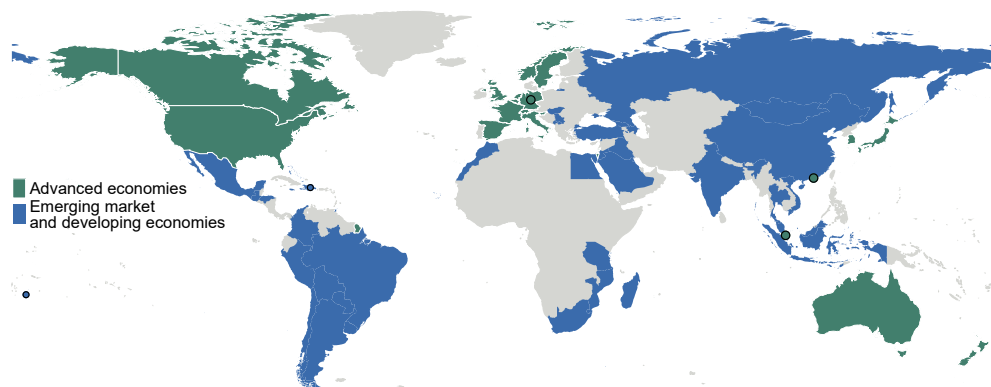
### 3 Comparison of CBDC's research and development across countries

In this chapter we will compare chosen countries and their approach to CBDC issuance, focusing namely on the potential benefits and risks. Many central banks are actively exploring CBDC.

The Bank for International Settlements (BIS) has conducted several yearly surveys on CBDC, which were responded to by central banks. It is evident from these surveys, that interest in the CBDC is growing and more and more central banks are researching the possibilities of CBDC.

In the first quarter of 2020, 65 central banks participated in the survey. These respondents represent approximately 72% of the world's population and 91% of global economic output. 21 of these central banks are located in advanced economies and 44 are in emerging market and developing economies (Boar and Wehrli, 2021). According to the findings from the survey, 60% of central banks are conducting experiments, which is 18% more than in the year 2019, and 14% of the central banks are moving forward with development and pilot arrangements.

**Figure 6: Respondents to the 2020 survey**



*Source: Boar and Wehrli (2021)*

In the first quarter of 2021, 50 central banks replied to the survey, whereas 18 respondents belong to the advanced economies and 32 to the emerging market and developing economies. Two-thirds of the central banks are conducting CBDC experiments or pilots (Auer et al., 2021a).



### The Bahamas – Sand Dollar

The Central Bank of The Bahamas (CBOB) is the first central bank in the world to launch CBDC. The CBDC of The Bahamas is called the Sand Dollar and it was launched on 20<sup>th</sup> October 2020. According to the official website of Sand Dollar, the Sand Dollar is the digital version of the Bahamian Dollar, and it is convertible to the Bahamian Dollar 1 to 1. The official currency of the Bahamas – the Bahamian Dollar is also pegged to the US Dollar, therefore, convertible with the US dollar 1 to 1, as well.

Sand Dollar's official website declares that Sand dollar allows greater flexibility and accessibility for residents that want to participate in financial services via either a mobile phone application (iOS and Android) or using a physical payment card to access a digital wallet. They also state that Sand Dollar provides an excellent record of income and spending, which can be used as supporting data for micro-loan applications.

The CBOB firstly introduced the Sand Dollar in a pilot phase in Exuma in December 2019 and later expanded the pilot Sand Dollar also to Abaco. Exuma was chosen due to its good representation of the whole Bahamas' geography and population. Abaco was chosen to test the CBDC after recovering from a natural disaster, which happened in 2019. The Exuma survey conducted by the CBOB showed a high rate of access to mobile devices and a willingness of more than half of residents to undertake more payment on digital platforms. The survey also revealed that more user-friendly and accessible financial services could persuade more Bahamian citizens to join the traditional banking services (CBOB, 2019).

The Bahamas is an archipelago consisting of more than 700 hundred islands and the population is quite dispersed. Many rural, family island communities have limited or even no access to automated banking machines and bank branches or they can access their services only through electronic channels. The distribution of cash is very costly and the access to banking services remained very limited for many people in the Bahamas (CBOB, 2019). This is important to mention because it was one of the reasons and motivations that led the CBOB to become the first country to officially launch CBDC. The CBOB conducted a survey in 2018 and it was found that *"about 93% of the surveyed respondents had knowledge*

*of savings accounts and 85% knew of checking accounts compared to a lesser 80% and 70% of the same individuals who used such instruments". However, from a payment perspective, "only 48% of individuals had access to credit card facilities, against awareness of these by 89% of those surveyed". The reasons for this exclusion were customer due diligence requirements and the high costs (CBOB, 2019).*

The project Sand Dollar is part of the Bahamian Payments System Modernisation Initiative (PSMI). The PSMI targets improved outcomes for financial inclusion and access, making the domestic payments system more efficient and non-discriminatory in access to financial services since the early 2000s. The main goals of the PSMI are that 100% Bahamian population has access to digital payment services, reduction of the size of unrecorded economic activities and full admission of micro, small and medium-sized businesses into the digital space (CBOB, 2019). The Sand Dollar can help to achieve these goals. According to the CBOB, the most important benefits of the Sand Dollar include financial inclusion, the reduction of the ill effects of cash usage, reduction of transaction costs and strengthened economic surveillance. The Bahamas is known as a tax haven and another benefit of the CBDC might be the better track of transactions, which could mitigate the risk of tax evasion.

In terms of the design and technology of the Sand Dollar, the CBOB has chosen a token-based solution using blockchain technology. The Sand Dollar "eco-system" is depicted in Figure 8. The CBOB cooperates with the decentralized wireless payment system provider NZIA Limited, which architected and implemented the digital currency system for the Bahamas. Key aspects of their solutions include interoperability, supporting "offline functionality", monitoring for fraud detection, and real-time transactions processing. The Sand Dollar is currently restricted for domestic use only. The wallet holders are still able to make electronic purchases of foreign exchange, thus they can use their account internationally. Regarding security, multi-factor authentication is being used for wallet users. Users have to supply two passcodes, one randomly generated, to complete some payments transactions (CBOB, 2019).

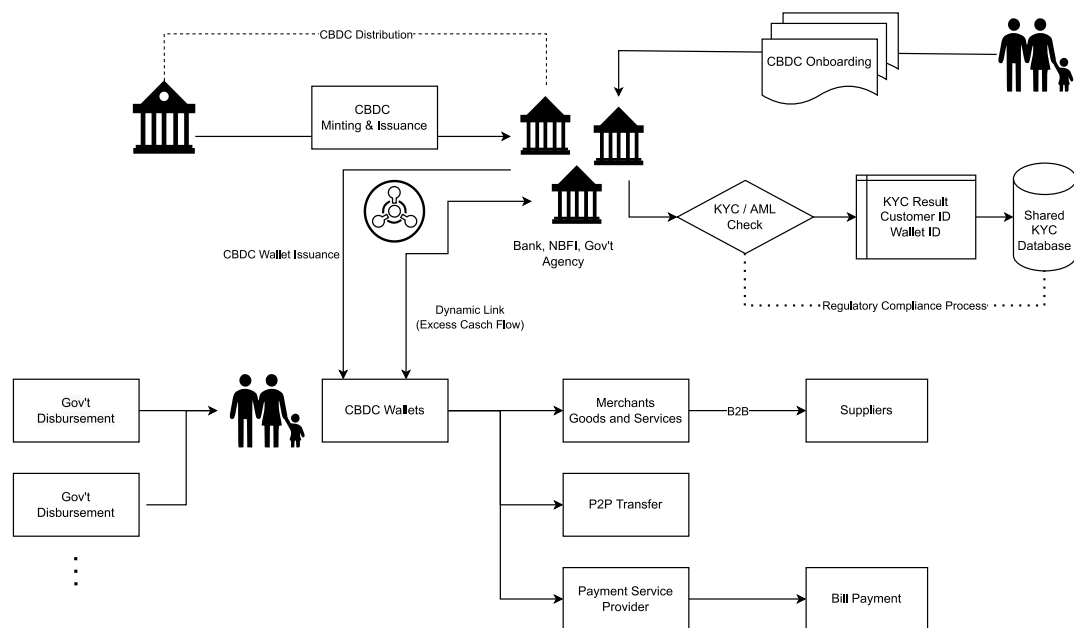
When taking into consideration the potential risks, namely the data and cybersecurity concerns and possible financial instability, the CBOB has developed the following solutions to mitigate these risks. The transactions are fully auditable, however, the CBOB set high regulations for protecting users' data and anonymity, as no personal information is ever

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

stored in the distributed ledger technology permissioned network. So that the Sand Dollar does not operate in practice as a substitute for traditional banking deposits, limits are placed on the amount of the Sand Dollar that individuals, businesses, and other non-supervised financial institutions can hold. These limits are depicted in Table 1. According to the type of account, there are also different KYC requirements, for the low-value account, no official ID is required, in contrast for the high-values/business accounts (CBOB, 2019).

In conclusion, Table 2 summarizes the contribution of CBDC, rather than talking about risks, the CBOB presents the necessary costs of the CBDC implementation.

**Figure 8: Digital Sand Dollar Eco-System**



Source: Central Bank of The Bahamas (2019)

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

**Table 1: Tiered KYC Requirements for Sand Dollar Accounts**

Type of account	Limits
Low-Value Accounts	Maximum Holding Limit: <b>B\$500</b> Maximum Transaction Limit <b>per month: B\$1,500</b>
Medium-Value (personal) Accounts	Maximum Holding Balance: <b>B\$5,000</b> Maximum Transaction Limit: <b>B\$10,000 per month</b> or <b>B\$100,000 per annum</b>
High-Value/Business Accounts	Maximum Holding Balance: <b>B\$8,000</b> , or 1/20th of annual sales, up to an annual limit B\$1 000 000 Maximum Transaction Limit per month: <b>B\$20,000</b> or 1/8th of annual revenues whichever is greater

Source: Autor's elaboration based on the CBOB (2019)

**Table 2: Costs and benefits of the Bahamian Digital Sand Dollar implementation**

COSTS	BENEFITS
Cost of services provided by the Technology Solutions Provider	Financial Inclusion - improved access to digital payments for the unbanked and underbanked
Ancillary costs related to preliminary work for the launch of the pilot	Lower transactions costs - reduced transaction costs for retail and institutional payments
Legal fees for external expertise on the required amendments to facilitate the issuance of digital currency	Economic growth and digital innovation – a creation of a new digital ecosystem can result in greater economic activity which can spill over into other technology sectors
Infrastructure expenses	Technology efficiency - faster settlement speed due to not having to rely on banks
Shared costs to establish a national identity infrastructure	Reduced rate of increase in cash production, storage, transportation, and costs.
	Improved information and enforcement for government tax administration; more efficient expenditure delivery for low-value payments
	Can encourage more competition in private payment systems and between financial institutions
	Better data coverage of economic activities for evidence-based policymaking

Source: Autor's elaboration based on the CBOB (2019)

### The Eastern Caribbean Central Bank - DCash

The Eastern Caribbean Central Bank (ECCB) was established in October 1983. The ECCB is the Monetary Authority for Anguilla, Antigua and Barbuda, Commonwealth of Dominica, Grenada, Montserrat, St Kitts and Nevis, Saint Lucia and St Vincent and the Grenadines (ECCB, 2019).

In 2019, the ECCB and the Barbados-based fintech company, Bitt Inc., signed a contract to conduct a blockchain-issued, token-based CBDC pilot within the Eastern Caribbean Currency Union (Finch et al., 2021). On 31<sup>st</sup> March 2021, the live version of the ECCB CBDC called "DCash" has been launched, only a few months later after the first CBDC was launched by The Bahamas. DCash is however the first CBDC launched by a currency union. There is a certain inconsistency regarding the ECCB CBDC in the literature, as certain sources state that the ECCB is still in the pilot phase and others state that it is already in the officially launched phase. Nevertheless, we believe it is valuable to discuss the DCash as it is one of very few launched CBDCs and it can be considered as a form of model example to other central banks both in positive and negative ways.

According to the official website of ECCB, DCash is considered legal tender under currently enacted legislation. However, cash will not be eliminated, and merchants will continue to accept it as a form of payment. The ECCB presents the following benefits of their CBDC – DCash, which are depicted in Table 3.

**Table 3: Benefits of the DCash:**

Pay or transfer money, without fees, in real-time
Simple steps and easy-to-use interfaces
A secure and safe platform to facilitate your DCash storage and transactions
The ability to send money instantly to family, friends, and businesses within the Eastern Caribbean Currency Union (ECCU)
No bank account is required
No minimum spending amount (as in the case of some card payment products)
No minimum balance is required to maintain your DCash account
Personal digital financial reports, provide real-time access to transaction records
Privacy and confidentiality of all the transaction information

*Source: Autor's elaboration based on the ECCB (2022)*

Neither in their official publications nor on the official website do the ECCB or the Bitt Inc. write about the risks or challenges that the DCash introduction could cause. Regarding private data security, the ECCB states that the DCash platform is being developed through security-by-design principles. The ECCB has decided to use Hyperledger Fabric technology software, which is being utilized to create an enterprise-grade, private-permissioned, distributed ledger (blockchain). Additionally, all DCash users must be authenticated and authorized. However, neither the ECCB nor Bitt Inc. does discuss the financial stability risks such as bank runs or financial disintermediation.

According to the official website of ECCB, the goal of the CBDC - DCash is to foster economic growth and improve competitiveness by reducing domestic payment inefficiencies and promoting financial inclusion. Tokens are available through a mobile wallet application, which facilitates payments or transfers using smart devices. DCash is available only with Internet access and only via iOS or Android smart devices with a camera.

### **Nigeria – eNaira**

The Central Bank of Nigeria (CBN) officially launched their CBDC called “eNaira” on 25<sup>th</sup> October 2021. Due to the size and complexity of Nigeria’s economy, this launch is drawing significant interest from the outside world (Ree, 2021).

The motivation of the Central Bank of Nigeria to create a CBDC arose from four sources, firstly, the issuance of CBDC by other central banks, secondly, the usage of cryptocurrencies by Nigerian citizens, thirdly, the potential for increased criminal activity connected with cryptocurrencies, and finally, the need for the many benefits of a trusted, government-issued digital currency for the Nigerian economy (Ozili, 2021). The CBN has worked together with the Barbados-based fintech company, Bitt Inc, which helped the CBN to create the blockchain-based technology that is used for eNaira, similarly to the ECCB in the previous section.

The eNaira official website states the following benefits, that the CBDC can bring. The eNaira can improve the drive towards a cashless policy and offer cash alternatives and reduce the dependence on cash. It



will increase financial inclusion because consumers do not need to have a bank account to hold a CBDC or the eNaira. The eNaira will also simplify cross-border transactions and make them cheaper and safer. Regarding the tax evasion concerns, this will become significantly more difficult as the eNaira will make taxable assets traceable and will enforce transparency in the taxation system, thereby increasing tax revenue to the government (CBN, 2021).

Like digital currencies elsewhere, the eNaira carries also risks, namely data and cyber security risks, financial stability risks and operational risks. The CBN states that data protection remains fundamental to the core design of the eNaira system and users will be able to determine how their data is used, shared, and processed. While users will have control of their data, the eNaira system is designed in line with AML/CFT guidelines to guide against the illicit flow and use of funds. The CBN claims that it is building a safe, trusted, and resilient payment system with a high level of integrity (CBN, 2022). The CBN is aware also of the financial instability risk and has restricted the eNaira payment system to micropayments. In addition, limits have been placed on wallets to enforce this. The limits placed on the eNaira are depicted in Table 4. The operational risks include failed dispute resolution mechanisms resulting in financial losses, especially for merchants, governance and decision making, and legal considerations around stakeholder obligations, responsibility for risks and exposures on the eNaira platform. The CBN states that it has considered these risks and provided adequate measures through the eNaira operational guidelines to mitigate them (CBN, 2022).

According to Ozili, despite all the risks, eNaira may solve more problems than it creates. He states that the risks it poses will provide an opportunity for the Central Bank of Nigeria to learn and improve the design of the eNaira and also improve its security features.

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

**Table 4: The eNaira Consumer Wallet Tier Structure:**

Tier	Category	Transaction Limit	The requirement to make payment	Regulatory validation
0	Non-Account Holders	Daily Transaction Limit: 20 000 Cumulative total: 120 000	Telephone Number (whose National Identification Number (NIN) is yet to be validated by NIMC)	Must provide passport photograph, name, place and date of birth, gender, address, and telephone number
1	Non-Account Holders	Daily Transaction Limit: 50 000 Cumulative total: 300 000	Telephone Number (whose NIN is already validated by NIMC)	Must provide passport photograph, name, place and date of birth, gender, address and telephone number
2	Account Holders	Daily Transaction Limit: 200 000 Cumulative total: 500 000	Bank Verification Number (BVN)	Must provide BVN, Tier 1 requirement plus evidence of ID
3	Account Holders	Daily Transaction Limit: 1 000 000 Cumulative total: 5 000 000	Bank Verification Number (BVN)	Full KYC requirement as stipulated in the CBN AML/CFT regulations

*Source: Autor's elaboration based on Ozili (2019)*

### 3.2 Pilot Project Phase CBDCs

The pilot project phase includes multiple countries, for the purpose of this work we have chosen Sweden and China, as they are the most advanced with their work. China is also one of the most populated countries in the world, therefore, the way they approach and handle the CBDC infrastructure, and its impact can influence also other big economies.

## Sweden

According to the Swedish Central Bank (further referred to as Riksbank), Sweden is currently one of the countries where digital payments are increasing the fastest (Riksbank, 2022a). Swedes tend to adapt to the benefits of technology rather swiftly and they prefer other means of payment over cash in purchases. Over eight years, a decline from 40 to 13 per cent was observed in paying in cash (Riksbank, 2018).

The Riksbank started to investigate its CBDC, called “e-krona” in 2017. In 2020, the Riksbank entered into a more practical phase of the e-krona project. To test how an e-krona might look and function, the Riksbank started a project, the e-krona pilot phase 1, together with the company Accenture, to construct a possible technical platform for the e-krona (Riksbank, 2022a). The Riksbank presents that the lessons learned from the first phase of the e-krona pilot project include that firstly, the technology provides new possibilities but requires further investigation, secondly, different forms of storage of tokens and keys provide different properties and finally, a parallel network makes the payment system more robust (Riksbank, 2021).

In February 2021, the Riksbank launched the second phase of the e-krona project and recently published the conclusions found during this second phase. During phase 2, the technical tests have included investigating whether and how an e-krona might function off-line, whether the performance of the tested solution is adequate, and how banks and other payment service providers could be integrated into an e-krona network. The latter has been tested in collaboration with Handelsbanken and Tietoevry. The results of phase 2 show that it is possible to integrate a potential e-krona into the internal systems the banks have today. That means that the bank clients would be able to exchange money in their bank account for the e-krona and vice versa. During this phase, Riksbank confirmed that it would be possible to make transactions using e-krona, even off-line. Nevertheless, these off-line payments bring also certain risks that need to be addressed before any similar solution becomes a reality (Riksbank, 2022b).

Armeliu et al. (2020) present the following benefits of the Swedish e-krona. It could present a form of risk-free money, available to the public. It would enhance competition and innovate payments. The e-krona

might serve as a backup payment method and also provide a good alternative to the private payments providers when it comes to privacy, the e-krona would not be based on a commercial interest to collect personal data. Lastly, it could promote faster, cheaper, and more efficient cross-border payments.

Regarding the risks, Riksbank states that in times of financial unease when the public wants to withdraw a large amount of money, the e-krona could make the bank run easier and quicker than a traditional run from the bank to cash. However, Riksbank already has the tools to be able to cope with such situations if they were thought to pose risks to financial stability (Riksbank, 2018b).

## China

The People's Bank of China (PBOC) has been at the forefront of CBDC research for several years, and it was also the first central bank that declared an intention to launch an official CBDC. In early 2016, the PBOC announced a "strategic goal" of launching a CBDC, which could enhance financial inclusion and efficiency in the payment system (Allen, Gu, and Jagtiani, 2022). Chinese CBDC is called the "e-CNY", their CBDC will be therefore further referred to as "e-CNY".

The development of e-CNY is closely related to the impact of cryptocurrencies on the monetary and financial system (Wu and Chen, 2021). In September 2017, the Chinese government banned initial coin offerings. The PBOC announced in September 2021 that all the activities related to cryptocurrencies and stablecoins are illegal (Allen, Gu, and Jagtiani, 2022).

The e-CNY is a legal tender, a liability of the central bank to the public, and a mainly substitute for cash in circulation (M0). Therefore, the e-CNY is certainly secure as it is backed by the sovereign credit of China. (PBOC Working Group, 2021). In late 2017, after approval by the State Council of China, the PBOC began to work with commercial institutions to develop and test the digital fiat currency, the e-CNY. After some years of work, in April 2020, the PBOC announced a set of trials in four cities (Shenzhen, Suzhou, Xiong'an, and Chengdu) to take place in preparation for the 2022 Winter Olympics in Beijing in early February (Allen, Gu, and

Jagtiani, 2022). This was considered to be an opportunity for the PBOC to raise awareness about the e-CNY. In November 2020, a few more cities including Shanghai, Hainan, and Changsha joined the CBDC pilots. *"Since January 2022, Tencent has launched e-CNY services on WeChat, and a number of other internet giants including JD.com and Didi Taxi have also started accepting e-CNY payments in trial cities. During the Winter Olympics, China has successfully tested the appeal of e-CNY by providing e-CNY's mobile application and payment cards or wristbands to visiting foreigners"* (Allen, Gu, and Jagtiani, 2022). The e-CNY is designed as a two-tier financial system, with the central bank responsible only for the wholesale accounts of financial intermediaries, and the latter continuing to be accountable to the public. The project requires authorized financial intermediaries to exchange and circulate e-CNY to the public, while the central bank is responsible for the issue and centralized management (PBOC, 2022).

One of the significant benefits the e-CNY will bring is the suppression of illegal financial activities, such as tele-fraud, online gambling, money laundering, tax evasion, and terrorism financing (PBOC Working Group, 2021). Kshetri (2022) presents the following benefits of the e-CNY to consumers, depicted in Table 5.

The most important risk the e-CNY possess is the privacy and data concern. To be able to use the e-CNY, the vast majority of users need to first bind their bank account to the digital wallet, which requires not only registering an account with their phone number but also requires the user to authenticate with their real name and bind their bank account (Cheng, 2022). The e-CNY is designed in a two-tier operating system, therefore, the central bank allocates quotas to designated commercial banks, which provide digital currency exchange and circulation services. However, these designated commercial banking industries have the opportunity to access users' e-CNY account information (PBOC Working Group, 2021). Nonetheless, when users' financial information is centralized, it can be potentially misused by the government or even targeted by criminals (Kshetri, 2022).

Regarding the financial stability concern, the PBOC proposes different levels of e-CNY holdings in the wallet and different requirements for users, similarly to the solutions proposed by the CBOB and CNB, mentioned in the previous section.

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

**Table 5: Key benefits of the e-CNY to consumers**

Benefit	Explanation	The effects of e-CNY
Reliable low-risk payment solution	More reliable means to carry out payment settlement compared to other available means  No clogging in the payment system	Private companies such as Alipay and WeChat pay face risks such as business failure and bankruptcy
Low costs and high efficiency	Faster transactions at lower costs	Indications that it will be free for vendors to accept the digital yuan payments  PBoC working with other jurisdictions to tackle inefficiencies and high costs
Promoting financial inclusion of disadvantaged groups	Traceability and the possibility to conduct transactions without a smartphone can promote financial inclusion of disadvantaged groups	The PBoC can monitor the flow of money and deliver targeted programs to improve the well-being of high-risk and disadvantaged groups  Dec. 2020 Suzhou trial: involved offline payments.

*Source: Autor's elaboration based on Kshitri (2022)*

Wu and Chen (2021) examined the mechanism of the e-CNY from both theoretical and practical perspectives. The e-CNY stands at the forefront of research, development, and implementation of CBDC in leading economies. Wu and Chen studied the economic effect of China's e-CNY on bank deposit substitution. They undertook a quantitative analysis based on a four-sector DSGE model. Their model included households, manufacturers, commercial banks, and central banks. They found out that the impact of e-CNY as a substitute for bank deposits is limited because the unit impact can increase the economic growth rate by 0,15%. The overall economic effect of e-CNY is positive, it can even reduce the leverage ratio to a certain degree, which helps to decrease systemic financial risk.

### 3.3 Research and Development Phase CBDCs

The research and Development Phase includes the highest number of countries which are actively exploring the CBDC. These include the USA, the UK, the Eurozone, Australia, Canada, Switzerland and also the Czech Republic. We have chosen to analyze the USA and the Eurozone as they belong to the strongest currency economies and even though, their CBDC work is not so advanced and tested as those of the above-mentioned countries, they represent together around 700 million people and their decisions will have a big impact on the rest of the world. The U.S. dollar is also the strongest reserve currency and several countries have their own currency pegged to the U.S. dollar such as the above-mentioned Bahamas.

#### **Eurozone – European Central Bank**

The European Central Bank (ECB) and the euro area national central banks carried out experimentation work on CBDC currently referred to as the “digital euro”. Following this work, they have launched the investigation phase of the project. The phase started in October 2021, and it will last for two years until October 2023. ECB stresses that the investigation of CBDC does not mean that they will necessarily issue a digital euro, but they are rather looking further into the possible scope and design of one, and how it could be distributed. The decision on whether to develop a digital euro will be taken based on this investigation phase.

In 2020 ECB released a comprehensive report on the digital euro with a focus on the possible design and functionalities. They also examine the impact of a digital euro on monetary policy, financial stability, banks' business models, international monetary spillovers and the oversight of services related to the digital euro. The report analysis focuses on the design of a digital euro for use in retail transactions available to the general public rather than designing only a wholesale type of CBDC available just to financial institutions.

Several factors motivated ECB to research the topic of CBDC. First, the digitalisation of the economy and technological innovations influence consumers' preferences and behaviour. Even though cash remains the dominant means of payment in the euro area as a whole, its use declined

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

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significantly in some countries. According to De Nederlandsche Bank estimates the share of cash transactions declined from 41% to 32% in the Netherlands between 2017 and 2019. COVID-19 pandemic stimulated the decrease of cash use even more, as more people turned to contactless payments. Second, according to recent ECB surveys, young Europeans use cash lot, however, they prefer electronic payments and expect the related infrastructure to guarantee safety and speed.

In their report, the term digital euro denotes *“a liability of the Eurosystem recorded in digital form as a complement to cash and central bank deposits”*. For the design of a digital euro, the ECB identifies core guiding principles based on current Eurosystem policies. These principles are depicted in Table 6.

**Table 6: Core principles**

P1	<b>Convertibility at par:</b> Not a parallel currency
P2	<b>Liability of the Eurosystem:</b> A digital euro is central bank money and its issuance is controlled by the Eurosystem
P3	<b>European solution:</b> Widely accessible on equal terms in all euro area countries through supervised service providers
P4	<b>Market neutrality:</b> Not to crowd out private solutions
P5	<b>Trusted by end-users:</b> Trusted solution from the start and overtime

*Source: Autor's elaboration based on Report on a digital euro (ECB, 2020)*

The ECB describes scenarios that could induce the Eurosystem to issue a digital euro and derives requirements that the new form of money should satisfy to address each specific scenario. These scenario-specific requirements are summarized in Table 7.

Regarding the benefits of CBDC, the ECB argues that a well-designed digital euro may help to reduce the overall costs and ecological footprint of euro area payment systems. The ECB further suggest that the issuance of a digital euro could support European sovereignty and stability, in particular in the monetary and financial dimensions. Moreover, by providing digital payments the Eurosystem could ensure that European citizens have access to payments at the technological frontier. *This would preserve the global reputation of the euro, not least if other major foreign central banks press ahead with issuing CBDC*” (ECB, 2020).



## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

**Table 7: Scenario-specific requirements**

R1	Enhanced digital efficiency (if launched to support digitalisation)
R2	Cash-like features (if aiming to tackle a decline in the acceptance of cash)
R3	Competitive features (if introduced to limit the uptake of forms of money that are not denominated in euro and/or not appropriately supervised)
R4	Monetary policy option: (if considered to be a tool for improving the transmission of monetary policy)
R5	Back-up system: (if aiming to improve the overall resilience of the payment system)
R6	International use (if introduced to increase the international role of the euro)
R7a	Cost saving (if launched for cost efficiency)
R7b	Environmentally friendly (if launched for environmental reasons)

*Source: Autor's elaboration based on Report on a digital euro (ECB, 2020)*

In the Report on a digital euro the ECB also examines the possible risks of CBDC and how they could be mitigated. Depending on the design of CBDC the depositors might transform their commercial bank deposits into CBDC, which could increase the funding costs of banks and lead to higher interest rates on bank loans. Substantial demand for digital euro may also have a negative impact on financial stability, given the key role of the banking sector in financial intermediation. When depositors lose trust in commercial banks and want to transfer their deposits into CBDC, it can increase the likelihood and severity of bank runs, weakening financial stability. Another risk is that a digital euro (CBDC) may attract cyberattacks with potential financial and business implications for several dimensions (ECB, 2020). To address the potential risks, the central bank should design the digital euro in line with the general requirements depicted in Table 8 (ECB, 2020).

### **The USA – The Federal Reserve System**

The United States of America (USA) published their report on CBDC later than other developed countries. According to the Atlantic Council of the countries with the 4 largest central banks (the USA, the Euro Area, Japan, and the UK), the United States is the furthest behind. The Federal Reserve System (FED), which is the central bank of the USA, published its long-awaited report on CBDC in January 2022. This report is the first step in a

## COMPARISON OF CBDC'S RESEARCH AND DEVELOPMENT ACROSS COUNTRIES

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**Table 8: General requirements**

R8	Ability to control the amount of digital euro in circulation
R9	Cooperation with market participants
R10	Compliance with the regulatory framework
R11	Safety and efficiency in the fulfilment of the Eurosystem's goals
R12	Easy accessibility throughout the euro area
R13	Conditional use by non-euro area residents
R14	Cyber resilience

*Source: Autor's elaboration based on Report on a digital euro (ECB, 2020)*

public discussion between the Federal Reserve and stakeholders about CBDCs. For the purpose of the report, FED defines CBDC as “*a digital liability of a central bank that is widely available to the general public*”. The FED stresses that their report does not guarantee that they will make an immediate decision on issuing a U.S. CBDC.

In the report, the FED states that CBDC should among others “*provide benefits to households, businesses, and the overall economy that exceed any costs and risks, yield such benefits more effectively than alternative methods, complement, rather than replace, current forms of money and methods for providing financial services, protect consumer privacy, protect against criminal activity, and have broad support from key stakeholders*”.

According to the analysis the FED has made so far, the U.S. CBDC would best serve the public if it is privacy-protected, intermediated, widely transferable, and identity-verified. Firstly, protecting the privacy of the consumers is critical as the users' financial transactions will generate data in the same ways that commercial banks and nonbank money generate such data today. Therefore, all financial institutions will have to comply with a robust set of rules. Secondly, the CBDC should be intermediated because The Federal Reserve Act does not authorize direct Federal Reserve accounts for individuals and these accounts would also represent a significant burden to the function of the FED. Even though private financial institutions would offer CBDC holdings and payments to the consumers, the CBDC itself would remain a liability of the FED. Thirdly, to serve as a widely accessible means of payment, the CBDC would need to be transferable among customers of different financial

intermediaries. Finally, the CBDC intermediary would need to verify the identity of the CBDC holders similarly to the identifications process the banks do nowadays. Therefore, in this regard, CBDC would not remain as anonymous as cash.

The FED proposes the following benefits. The CBDC presents a safe foundation for private-sector innovations to meet current and future needs and demands for payment services. The CBDC has a potential to make cross-border payments simpler and more interoperable. The American dollar is currently the world's most widely used currency for payments and investment and it also serves as the world's reserve currency. The U.S.-issued CBDC could help to preserve this dominant international role of the American dollar. Furthermore, the CBDC could reduce common barriers to financial inclusion and also lower transactions, which would be useful, especially for low-income households. Last but not least, as cash used in the United States declines consumers might want the option of digitized central bank money that, like cash, would have no credit or liquidity risk attached to it. CBDC would be a good solution for this (Board of Governors of the FED, 2022).

Although the introduction of a CBDC could benefit U.S. consumers and the broader financial system, the FED states that it would also raise complex policy issues and risks. Firstly, CBDC could change the financial market structure because a widely accessible CBDC would serve as a substitute for commercial bank money. This substitution effect could reduce the aggregate amount of deposits in the banking system, which could in turn increase bank funding expenses, and reduce credit availability or raise credit costs for households and businesses. Secondly, CBDC would be particularly attractive to risk-averse users, especially during times of stress in the financial system, which could make bank runs more likely and severe. Thirdly, the CBDC would need to strike an appropriate balance between safeguarding consumer privacy rights and affording the transparency necessary to deter criminal activity. Finally, the traditional threats to existing payment services such as operation disruption and cybersecurity risks would apply to CBDC, as well (Board of Governors of the FED, 2022).

## 4 Evaluation of risks and benefits of CBDC

In this chapter, we present an analysis of the possible benefits and risks of the CBDC, as CBDC can provide great advantages and improvements, however, when the risks are underestimated, it can have a severe impact on the whole economy. We derive our comparison based on the approaches to the CBDC benefits and risks presented by the chosen countries. The summary of the benefits and risks proposed by the countries from chapter 3 is depicted in Table 9.

The relative importance of different benefits differs across economies. A survey of 63 central banks, 41 located in emerging market economies (EMEs) and 22 in advanced economies, found that EMEs value domestic payments efficiency and financial inclusion as the top two benefits of CBDCs. Cross-border payments efficiency was the least important benefit for EMEs. Central banks in advanced economies, on the other hand, considered payments safety and financial stability as the primary benefits of CBDCs. Financial inclusion was considered to be the least important factor by this group of economies (Barontini, 2019).

According to our literature review of chosen countries and the approach to benefits and risks of CBDCs we found similar results as Barontini (2019). The Bahamas, The ECCU, Nigeria and China, which can be classified as emerging market economies, present financial inclusion as an important benefit and motivation for issuing CBDCs. On the other hand, Sweden, Eurozone, and the USA mention financial inclusion only as one of the possible benefits of CBDCs, they focus more on the alternative to the declined use of cash, and they thoroughly explore the impact on the financial and monetary system. From Table 9 and also section 3.3 Research and Development Phase CBDCs, we can see that the FED and the ECB focus a lot on the risks in comparison to the Bahamas, Nigeria and the ECCU, which present that CBDC is rather beneficial than risky.

The reason why such an advanced and powerful economy as the USA waits so long with the research of the CBDC, could be explained by the quote of Jerome Powell, the chairman of the Federal Reserve System that he said at the panel discussion Cross-Border Payments—A Vision for the Future (2020): *“It's more important for the United States to get it right than to be the first. Getting it right means we not only look at the potential benefits of CBDCs, but also the potential risks, and also recognize the important tradeoffs that have to be thought through carefully”*.

**Table 9: Summarized comparison of CBDC benefits and risks of the above-analyzed countries**

	<b>Benefits</b>	<b>Risks</b>
The Bahamas	<ul style="list-style-type: none"> <li>- financial inclusion</li> <li>- reduced ill effects of cash</li> <li>- reduced transaction costs</li> <li>- better track of transactions -&gt; improved tax evasion risk</li> </ul>	<ul style="list-style-type: none"> <li>- cybersecurity and data privacy risk</li> <li>- financial stability risk</li> </ul>
The Eastern Caribbean Central Union	<ul style="list-style-type: none"> <li>- financial inclusion</li> <li>- pay or transfer money, without fees, in real-time</li> <li>- simple steps and easy-to-use interfaces</li> <li>- a secure and safe platform to facilitate your DCash storage and transactions</li> <li>- the ability to send money instantly to family, friends, and businesses within the ECCU</li> <li>- no bank account required</li> <li>- no minimum spending amount (as in the case of some card payment products)</li> <li>- no minimum balance required to maintain your DCash account</li> <li>- personal digital financial reports, provide real-time access to transaction records</li> <li>- privacy and confidentiality of all the transaction information</li> </ul>	<ul style="list-style-type: none"> <li>- not discussed</li> </ul>
Nigeria	<ul style="list-style-type: none"> <li>- financial inclusion</li> <li>- good cash alternative</li> <li>- reduced dependence on cash</li> <li>- simpler, cheaper, and safer cross-border transactions</li> </ul>	<ul style="list-style-type: none"> <li>- cybersecurity and data privacy risk</li> <li>- financial stability risk</li> <li>- operational risks</li> </ul>

Table 9 continues

Sweden	<ul style="list-style-type: none"> <li>- risk-free money, available to the public</li> <li>- enhanced competition</li> <li>- innovative payments</li> <li>- faster, cheaper, and more efficient cross-border payments</li> </ul>	<ul style="list-style-type: none"> <li>- financial instability</li> <li>- bank runs</li> </ul>
China	<ul style="list-style-type: none"> <li>- suppression of illegal financial activities</li> <li>- a reliable low-risk payment solution</li> <li>- low-costs and high efficiency</li> <li>- promoting financial inclusion of disadvantaged groups</li> </ul>	<ul style="list-style-type: none"> <li>- cybersecurity and data privacy risk</li> <li>- financial stability risk</li> </ul>
The Eurozone	<ul style="list-style-type: none"> <li>- support of sovereignty and stability</li> <li>- technologically advanced payments</li> <li>- improved cross-border payments</li> <li>- reduced overall costs and ecological footprint of euro area payment systems</li> </ul>	<ul style="list-style-type: none"> <li>- increased funding costs of banks, leading to higher interest rates on bank loans</li> <li>- financial stability risk</li> <li>- bank runs</li> <li>- cybersecurity and data privacy risk</li> </ul>
The USA	<ul style="list-style-type: none"> <li>- safely meet future needs and demands for payment services</li> <li>- improved cross-border payments</li> <li>- support the dollar's international role</li> <li>- financial inclusion</li> <li>- extended public access to safe central bank money</li> </ul>	<ul style="list-style-type: none"> <li>- changes to financial sector market structure</li> <li>- safety and stability risks</li> <li>- efficacy of monetary policy implementation</li> <li>- privacy and data protection risks</li> <li>- operational resilience and cybersecurity risks</li> </ul>

Source: Autor's elaboration

Regarding the design and technology, we have found that all the launched CBDCs use some form of decentralized ledger technology, whereas the USA and the Eurozone are open also to other technical solutions. Sweden and China are somewhere in the middle, as they focused on their pilot phases also on the possibility of using decentralized ledger technology. The technology and design can be considered as an important attribute because each technology presents different form of benefits and risks.

We believe that by issuing CBDC, the Bahamas, Nigeria, and the ECCB try to improve and address the inefficiency in their banking sector and provide advanced financial service to the broader public. CBDC can help to better track the financial transactions and could be used as an additional monetary tool. Another benefit, these emerging countries might want to achieve, is the bigger independence from the strong reserve currencies.

On the other hand, the USA and the Eurozone might want to keep their strong position, as their currencies – the U.S. dollar and the euro belong to the strongest currencies in the world, the U.S. dollar being world reserve currency. The decline of cash use can cause higher concentration of transactions in the hand of private financial institutions such as commercial banks and it would be harder for the central banks to provide all their monetary goals. This is the case that can be seen in northern European countries, especially in Sweden. The CBDC would present a good benefit for this problem.

Bank runs present a significant risk to the financial stability, however multi-tier CBDC system and limit on CBDC holdings might help to keep this risk to minimum. We believe that the biggest concern is the data privacy. On one hand central banks might be safer institutions to collect data from citizens as they do not focus on marketing and business goals such as commercial banks, however, on the other hand, when the political regime is not democratic and central bank is not an independent institution, it can pose a serious threat to the privacy of the citizens.

Even though, CBDC is connected also with risks and additional costs, we believe that if central banks remain cautious and thoroughly prepare for the bad case scenarios, the benefits will be more dominant and CBDC will become an effective and fast addition to the current financial and payment services.

In conclusion, according to the results and findings of Lee, Yan, and Wang (2021), CBDC will become the primary tool in the future digital economy, and they believe countries that already research and implement CBDC in their economy will gain a competitive advantage.

### Conclusion

The central bank digital currency (CBDC) is getting more and more attention in the recent years. In the simplest way CBDC can be perceived as a digital form of banknotes and coins, similarly to the cash CBDC would be a direct liability of the central bank. It may seem that central banks already provide digital form of money and payments, however the existing forms of digital payments solution are provided directly by the central banks only to the commercial banks and other financial institutions, which serve as intermediaries and provide this service further to the customers. Therefore, when we pay by a credit card, the money we spend is not a direct liability to the central bank, but only to our payment system provider such as our commercial bank.

In this thesis we analyzed the possible benefits and risks the CBDC entails. Financial inclusion, reduced reliance on payments service providers, better detection of illegal activities, additional policy instrument, more efficient retail payments and faster, cheaper, and more resilient cross-border payments, these are the generally proposed benefits of CBDC. On the other hand, there are two main categories of risks the CBDC poses. Firstly, the CBDC might cause disruption of the financial stability, namely creating a possibility for financial disintermediation and bank runs. Secondly, there is the risk of keeping the data privacy and cyber-attacks.

When comparing the CBDC across the chosen countries we have found out that there are different approaches to the benefits and risks of CBDC between the emerging market economies (EMEs) and the advanced market economies (AMEs), as the EMEs focus on the financial inclusion as the main benefit, whereas the AMEs put in the foreground the ability to keep the important position of their central banks and their currency, which is the case of the USA and the Eurozone.

Taking into consideration the results we found by the analysis of the approaches of the above-mentioned countries we believe that CBDC is a very important topic and presents a great opportunity to improve current inefficiencies and problems in the financial sector. Moreover, CBDC could help maintain the important role and position of the central bank.

Regarding the future development of the CBDC, we believe that most central banks will decide to issue CBDC sooner or later. Most probably the central banks of the AMEs countries will rather wait how the CBDC



works and whether it is safe and efficient in the countries, which already implemented the CBDC and modify their decisions according to these findings. The most advanced economies might motivate each other to accelerate the research and development of CBDC as the one that issues CBDC first, might set the trends and standards for the rest of them.

## References

1. AGUR, Itai, Anil ARI a Giovanni Dell ARICCIA. 2021. Designing central bank digital currencies. *Journal of Monetary Economics*. [online]. [cited 04-02-2022]. ISSN 0304-3932. Available from: <https://ideas.repec.org/a/eee/moneco/v125y2022icp62-79.html>
2. ALLEN, Franklin, GU, Xian and Julapa JAGTIANI. 2022. Fintech, Cryptocurrencies, and CBDC: Financial Structural Transformation in China. *Journal of International Money and Finance*. [online]. [cited 23-04-2022]. Volume 124, 2022, ISSN 0261-5606 Available from: <https://doi.org/10.1016/j.jimonfin.2022.102625>.
3. ARMANTIER, Oliver, DOERR, Sebastian, FROST, Jon, FUSTER, Andreas, and Kelly SHUE. 2021. *Whom do consumers trust with their data? US survey evidence*, BIS Bulletins, no 42, May. [online]. [cited 16-04-2022]. Available from: <https://www.bis.org/publ/bis-bull42.pdf>
4. ARMELIUS, Hanna, GUIBOURG, Gabriela, JOHANSSON, Stig and Johan SCHMALHOLZ. 2020. E-krona design models: pros, cons and trade-offs. *Sveriges Riksbank Economic Review*, Second special issue on the e-krona. [online]. [cited 23-04-2022]. ISSN 2001-029X. Available from: <https://www.riksbank.se/globalassets/media/rapporter/pov/engelska/2020/economic-review-2-2020.pdf>
5. AUER, R., G. CORNELLI, and J. FROST. 2020. *Rise of the Central Bank Digital Currencies: Drivers. Approaches and Technologies*. [online]. [cited 04-03-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/work880.pdf>
6. AUER, Raphael, and Rainer BÖHME. 2021. *Central bank digital currency: the quest for minimally invasive technology*. [online]. [cited 02-04-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/work948.htm>
7. AUER, Raphael, BOAR, Codruta, CORNELLI, Giulio, FROST, Jon, HOLDEN Henry, and Andreas WEHRLI. 2021a. *CBDCs beyond borders: results from a survey of central banks*. [online]. [cited 31-03-2022]. Basel, Switzerland: Bank For International Settlements. Available from: <https://www.bis.org/publ/bppdf/bispap116.htm>

8. AUER, Raphael, FROST, Jon, GAMBACORTA, Leonardo, MONNET, Cyril, RICE, Tara, and Hyung Song SHIN. 2021b. *Central bank digital currencies: motives, economic implications and the research frontier*. [online]. [cited 02-04-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/work976.htm>
9. AUER, Raphael, HAENE, Philipp and Henry HOLDEN. 2021. *Multi-CBDC arrangements and the future of cross-border payments*. [online]. [cited 04-04-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/bppdf/bispap115.htm>
10. Bank for International Settlements (2021): “*Central bank digital currencies: an opportunity for the monetary system*”, Annual Economic Report, Chapter III, June. [online]. [cited 16-04-2022]. Available from: <https://www.bis.org/publ/arpdf/ar2021e3.htm>
11. Bank for International Settlements, The Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors of the Federal Reserve. 2020. *Central bank digital currencies: foundational principles and core features*, Joint Report [online]. [cited 11-04-2022]. ISBN: 978-92-9259-427-5 (online). Available from: <https://www.bis.org/publ/othp33.htm>
12. BARONTINI, Christian and Henry HOLDEN. 2019. *Proceeding with caution—a survey on central bank digital currency*. Bank for International Settlements. [online]. [cited 25-04-2022]. Available from: <https://www.bis.org/publ/bppdf/bispap101.pdf>
13. BINDSEIL, Ulrich. 2019. Central Bank Digital Currency: Financial System Implications and Control. *International Journal of Political Economy*. Abingdon: Routledge Journals, Taylor & Francis Ltd. [online]. [cited 01-03-2022]. vol. 48, issue 4, pages 303-335. ISSN 0891-1916. Available from: doi:10.1080/08911916.2019.1693160.
14. BIS Innovation HUB, Committee on Payments and Market Infrastructures, International Monetary Fund (IMF) and World Bank. 2021. *Central bank digital currencies for cross-border payments*. Joint Report to the G20. [online]. [cited 04-04-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/othp38.htm>

## REFERENCES

---

15. BITTER, Lea. 2020. *Banking Crises under a Central Bank Digital Currency (CBDC)*, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2020: Gender Economics, ZBW - Leibniz Information Centre for Economics, Kiel, Hamburg. [online]. [cited 14-04-2022]. Available from: <https://www.econstor.eu/bitstream/10419/224600/1/vfs-2020-pid-40056.pdf>
16. BOAR Codruta and Andreas WEHRLI. 2021. *Ready, steady, go? – Results of the third BIS survey on central bank digital currency*. [online]. [cited 30-03-2022]. Basel, Switzerland: Bank for International Settlements. Available from: <https://www.bis.org/publ/bppdf/bispap114.pdf>
17. Board of Governors of The Federal Reserve System. 2022. *Money and Payments: The U.S.Dollar in the Age of Digital Transformation*, [online]. [cited 23-03-2022]. Available from: <https://www.federalreserve.gov/publications/money-and-payments-discussion-paper.htm>
18. BULLMANN, Dirk, Jonas KLEMM and Andrea PINNA. 2019. *In search for stability in crypto-assets: are stablecoins the solution?* [online]. [cited 01-02-2022]. Available from: <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op230~d57946be3b.en.pdf>
19. Central Bank of Nigeria. 2022. *Design Paper for the eNaira*. [online]. [cited 21-04-2022]. Available from: <https://www.enaira.gov.ng/about/design>
20. Central Bank of The Bahamas. 2018. *Analysis of The Bahamas Financial Literacy Survey 2018* [online]. [cited 20-04-2022]. Available from: <https://www.centralbankbahamas.com/news/general-news/analysis-of-the-bahamas-financial-literacy-survey-2018>
21. Central Bank of The Bahamas. 2019. *PROJECT SAND DOLLAR: A Bahamas Payments System Modernisation Initiative*. [online]. [cited 16-04-2022]. Available from: <https://www.centralbankbahamas.com/publications/main-publications/project-sanddollar-a-bahamian-payments-system-modernization-initiative>
22. CHENG, Pangyue. 2022. *Decoding the rise of Central Bank Digital Currency in China: designs, problems, and prospects*. J Bank Regul (2022). [online]. [25-04-2022]. Available from: <https://doi.org/10.1057/s41261-022-00193-5>

23. DIAMOND, Douglas Warren, and Philip H. DYBVIG. 1983. Bank runs, deposit insurance and liquidity. *Journal of Political Economy* 91, pages 401-419. [online]. [cited 18-03-2022]. Available from: <https://www.journals.uchicago.edu/doi/abs/10.1086/261155>
24. Eastern Caribbean Central Bank. 2019. *ECCB to Issue World's First Blockchain-based Digital Currency*. [online]. [cited 21-04-2022]. Available from: <https://www.eccb-central-bank.org/news/view/eccb-to-issue-worldas-first-blockchain-based-digital-currency>
25. Eastern Caribbean Central Bank. 2020. *ECCB Digital EC Currency Pilot*. [online]. [cited 21-04-2022]. Available from: <https://www.eccb-centralbank.org/p/about-the-project>
26. European Central Bank. 2020. *Report on a digital euro*, [online]. [cited 23-03-2022]. Available from: [https://www.ecb.europa.eu/pub/pdf/other/Report\\_on\\_a\\_digital\\_euro~4d7268b458.en.pdf](https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf)
27. FERNANDEZ-VILLAVARDE, Jesús, SANCHES, Daniel, SCHILLING, Linda, a Harald UHLIG. 2021a. Central bank digital currency: Central banking for all? *Review of Economic Dynamics*. San Diego: Academic Press Inc Elsevier Science. [online]. [cited 18-03-2022]. vol. 41, pages 225-242. ISSN 1094-2025. Available from: doi:10.1016/j.red.2020.12.004.
28. FERNANDEZ-VILLAVARDE, Jesús, SCHILLING, Linda, a Harald UHLIG. 2021b. *Central bank digital currency: when price and bank stability collide*. CEPR Discussion Paper No. DP15555. [online]. [cited 08-04-2022]. Available from: <https://ssrn.com/abstract=3753955>
29. FINCH, Kevin, GARCIA-SINGH, Chantal and Kateri DUKE. 2021. Caribbean Currency Convertibility in an Era of Central Bank Digital Currency. [online]. [cited 20-04-2022]. Available from: [https://www.bis.org/events/cpmi\\_ptfop/proceedings/paper9.pdf](https://www.bis.org/events/cpmi_ptfop/proceedings/paper9.pdf)
30. FOLEY, Sean, KARLSEN, Jonathan and Talis PUTNINŠ. 2019. Sex, drugs, and bitcoin: how much illegal activity is financed through cryptocurrencies?, *Review of Financial Studies*. [online]. [cited 22-02-2022]. vol 32, no 5, pp 1798–853. Available from: <https://ideas.repec.org/a/oup/rfinst/v32y2019i5p1798-1853..html>
31. <https://www.sanddollar.bs/about>, [online]. [cited 20-04-2022].

## REFERENCES

---

32. KEISTER, Todd and Cyril MONNET. 2021. Information, privacy and central bank digital currency. *Central Bank Digital Currency Considerations, Projects, Outlook*. Centre for Economic Policy Research, edited by Dirk NIEPELT. 2021. ISBN: 978-1-912179-54-1. [online]. [cited 16-04-2022]. Available from: <https://voxeu.org/content/central-bank-digital-currency-considerations-projects-outlook>
33. KIFF, John, ALWAZIR, Jihad, DAVIDOVIC, Sonja, FARIAS, Aquiles, KHAN Ashraf, KHIAONARONG, Tanai, MALAIKA, Majid, MONROE, Hunter K, SUGIMOTO, Nobu, TOURPE, Hervé and Peter ZHOU. 2020. *A Survey of Research on Retail Central Bank Digital Currency*. [online]. [cited 15-03-2022]. Washington, DC: International Monetary Fund (IMF). Available from: <https://www.imf.org/en/Publications/WP/Issues/2020/06/26/A-Survey-of-Research-on-Retail-Central-Bank-Digital-Currency-49517>
34. KSHETRI, Nir. 2022. *China's Digital Yuan: motivations of the Chinese Government and Potential Global Effects*. *Journal of Contemporary China*. [online]. [25-04-2022]. Available from: <https://doi.org/10.1080/10670564.2022.2052441>
35. KUMHOF, Michael and Clare NOONE. 2021. Central bank digital currencies — Design principles for financial stability. *Economic Analysis and Policy*. Amsterdam: Elsevier. [online]. [cited 10-03-2022]. vol. 71, s. 553-572. ISSN 0313-5926. Available from: <https://ideas.repec.org/a/eee/ecanpo/v71y2021icp553-572.html>
36. KUMHOF, Michael, and Claire NOONE. 2018. *Central Bank Digital Currencies - Design Principles and Balance Sheet Implications*. [online]. [cited 08-02-2022]. London, United Kingdom: Bank of England. Available from: <https://www.bankofengland.co.uk/-/media/boe/files/working-paper/2018/central-bank-digital-currencies-design-principles-and-balance-sheet-implications>
37. LEE, David Kuo Chuen, YAN, Li, and Yu WANG. 2021. A global perspective on central bank digital currency. *China Economic Journal*. Abingdon: Routledge Journals, Taylor & Francis Ltd. [online]. [cited 11-02-2022]. vol. 14, issue 1, pages 52-66. ISSN 1753-8963. Available from: doi:10.1080/17538963.2020.1870279.
38. LUTHER, William J. and Lawrence H. WHITE. 2014. *Can Bitcoin Become a Major Currency?* [online]. [cited 01-02-2022]. George Mason University Department of Economics Working Paper No. 14-17

- Available from: [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2446604](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2446604)
39. MAS and Bank of Canada. 2019. *Jasper - Ubin Design Paper*. Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies. [online]. [cited 05-02-2022]. Monetary Authority of Singapore. Available from: <https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf>
  40. OZILI, Peterson K. 2021. *Central Bank Digital Currency in Nigeria: Opportunities and Risks*. [online]. [cited 20-04-2022]. Available from: <http://dx.doi.org/10.2139/ssrn.3917936>
  41. People's Bank of China. 2021. Working Group on E-CNY Research and Development of the PBOC. Beijing, China: *Progress of Research and Development of E-CNY in China*. [online]. [cited 25-04-2022]. Available from: <http://www.pbc.gov.cn/en/3688110/3688172/4157443/4293696/2021071614584691871.pdf>
  42. POWELL, Jerome. 2020. Cross-Border Payments—A Vision for the Future. [online]. [cited 25-04-2022]. Available from: <https://meetings.imf.org/en/2020/Annual/Schedule/2020/10/19/imf-cross-border-payments-a-vision-for-the-future>
  43. QIAN, Yao. 2019. Central Bank Digital Currency: optimization of the currency system and its issuance design. *China Economic Journal*. Abingdon: Routledge Journals, Taylor & Francis Ltd. [online]. [cited 05-04-2022]. vol. 12, issue 1, pages 1-15. ISSN 1753-8963. Available from: doi:10.1080/17538963.2018.1560526.
  44. REE, Jack. 2021. *Five Observations on Nigeria's Central Bank Digital Currency*. IMF African Department. [online]. [cited 21-04-2022]. Available from: <https://www.imf.org/en/News/Articles/2021/11/15/na111621-five-observations-on-nigerias-central-bank-digital-currency>
  45. Riksbank. 2018a. *Payments patterns in Sweden 2018*. [online]. [cited 23-04-2022]. Available from: <https://www.riksbank.se/globalassets/media/statistik/betalningsstatistik/2018/payments-patterns-in-sweden-2018.pdf>
  46. Riksbank. 2018b. *The Riksbank's e-krona project Report 2*. [online]. [cited 23-04-2022]. Available from:



## REFERENCES

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- <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2018/the-riksbanks-e-krona-project-report-2.pdf>
47. Riksbank. 2021. *E-krona pilot phase 1*. [online]. [cited 23-04-2022]. Available from: <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2021/e-krona-pilot-phase-1.pdf>
48. Riksbank. 2022a. *E-krona* [online]. [cited 23-04-2022]. Available from: <https://www.riksbank.se/en-gb/payments--cash/e-krona/>
49. Riksbank. 2022b. *E-krona pilot phase 2*. [online]. [cited 23-04-2022]. Available from: <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2022/e-krona-pilot-phase-2.pdf>
50. SANCHEZ-ROGER, Marc and Esther PUYOL-ANTÓN. 2021. *Digital Bank Runs: A Deep Neural Network Approach*. Sustainability 2021, 13(3), 1513; [online]. [cited 14-04-2022]. Available from <https://doi.org/10.3390/su13031513>
51. SANCHEZ-ROGER, Marc, OLIVER-ALFONSO, María, Dolores, and Carlos, SANCHIS-PEDREGOSA. 2018. *Bail-In: A Sustainable Mechanism for Rescuing Banks*. Sustainability 2018, 10, 3789. [online]. [cited 14-04-2022]. Available from: <https://doi.org/10.3390/su10103789>
52. TOBIN, James, 1987. The case for preserving regulatory distinctions. *Proceedings - Economic Policy Symposium*. Jackson Hole, Federal Reserve Bank of Kansas City, pages 167-205.
53. WANG, Ziijan. 2020. *Tax Compliance, Payment Choice, and Central Bank Digital Currency*. [online]. [cited 16-04-2022]. Available from: <http://dx.doi.org/10.2139/ssrn.3755573>
54. WU, Tong and Jiayou CHEN. 2021. A study of the economic impact of Central Bank Digital Currency under global competition. *China Economic Journal*. Abingdon: Routledge Journals, Taylor & Francis Ltd, [online]. [cited 01-02-2022]. vol. 14, issue 1, pages 78-101. ISSN 1753-8963. Available from: doi:10.1080/17538963.2020.1870282.