

Central Bank Digital Currency: research streams – a literature review

Dr. Alfreda Šapkauskienė

Vilniaus universiteto Ekonomikos ir verslo administravimo fakultetas,
Finansų katedros vedėja, profesorė
Vilnius University, Faculty of Economics and Business Administration,
Head of Finance Department, Professor
El. p.: alfreda.sapkauskiene@evaf.vu.lt
ORCID: <https://orcid.org/0000-0002-0070-4097>

Ineta Prialgauskaitė

Vilniaus universiteto Ekonomikos ir verslo administravimo fakultetas,
Finansų ir bankininkystės magistro studijų programos studentė
Vilnius University, Faculty of Economics and Business Administration,
Master student of Finance and Banking study program
El. p.: ineta.prialgauskaite@evaf.stud.vu.lt

Summary. Each type of payment - whether it would be coins and notes, electronic bank transfer, or remittance via fractions of bitcoin - could lead to a considerable number of benefits, as well, could possess a substantial number of risks or even threats to the current financial system and stability. The relatively recent concept of payment - cryptocurrencies, especially central bank digital currencies (CBDCs) - from a historical point of view, remains a mystery with only a few central banks to date launching these particular digital currencies. Since fundamental decisions in the development of CBDCs are taking place nowadays, it highlights the importance of a thorough review of already existing theoretical research with a view to determining various assessments and blind spots, before introducing CBDCs in the wider markets and usage. The scientific literature about CBDC was analysed using an extensive and systematic study of available research publications, their categorization, and summarizing. The authors offer a new glance toward a systemization of available scientific literature with a focus on CBDC. This novel suggestion of dividing research areas supports the idea of the end-to-end product life-cycle and comes into four different groups: motivations, design features, demands, and final impact on monetary sovereignty and the financial system as a whole. The unknown level of CBDC's demand or expression of design features encourages researchers to consider various theoretical implications before CBDC will be creating major shifts in the banking industry or financial ecosystem.

Keywords: CBDC, central banks, research streams, digital currency.

Centrinio banko skaitmeninė valiuta: tyrimų kryptys – literatūros apžvalga

Santrauka. Kiekvienas mokėjimo būdas – monetos ar banknotai, elektroninis bankinis pavedimas ar atsiskaitymas bitkoinais teikia privalumą, bet tuo pačiu gali sukelti ir tam tikras rizikas ar net grėsmes dabartinei finansų sistemai ir jos stabilumui. Kriptovaliutos, ypatingai centrinių bankų skaitmeninės valiutos, yra naujas ir istorinio precedento neturintis konceptas finansų sistemoje. Šiuo metu dar tik kelių šalių centriniai bankai yra išleidę

Received: 26/04/2023. **Accepted:** 12/05/2023

Copyright © Alfreda Šapkauskienė, Ineta Prialgauskaitė, 2023. Published by Vilnius University Press.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

naudojimui tinkamas centrinių bankų skaitmenines valiutas, todėl yra būtina prieš pradėdant jas plačiai diegti bei naudoti rinkose, išsamiai išanalizuoti jau atliktus teorinius tyrimus ir bei identifikuoti problemines sritis, kuriose vis dar reikia rasti tinkamus sprendimus siekiant, kad centrinių bankų skaitmeninės valiutos užtikrintų finansų rinkų bei vartotojų poreikius. Mokslinė literatūra, apžvelgianti centrinio banko skaitmeninę valiutą buvo išanalizuota pasitelkiant sistematinis lyginamuosius metodus, sugrupuojant publikacijas pagal autorių pasirinktus kriterijus ir juos apibendrinant. Straipsnyje atlikta išsami mokslinės literatūros analizė, pasirenkant naują tyrimų grupavimo būdą būdingą produkto cikliškumui (motyvacija išleisti CBDC, dizaino ypatumai, paklausos prognozė ir poveikis finansų sistemai). Kol kas nežinoma naujos skaitmeninės valiutos paklausa ar techninių sprendimų išraiška skatina mokslininkus apsvarstyti ir įvertinti įvairias teorines galimybes kaip ši valiuta gali reikšmingai paveikti kiekvienos šalies bankinę sistemą ar finansų ekosistemą.

Reikšminiai žodžiai. centrinio banko skaitmeninė valiuta; centriniai bankai; tyrimų sritys; skaitmeninė valiuta.

Introduction

Due to its novelty and lack of historical precedent, during the last few years, the theoretical accounts for central bank digital currency (or in short - CBDC) have expanded a lot and the definition of the concept itself is getting clearer. According to International Monetary Fund (2020), CBDC could be outlined as a widely accessible virtual/digital form of fiat money issued as a liability of the central bank or any other monetary authority and serving as a part of the base money supply. Ferrari-Minesso et al. (2022) conclude that CBDC could be seen as a concept – ‘reserves for all’, i.e., reserves of the central bank could be accessed not only by commercial banks but by the general public, while Bindseil (2019) adds that CBDC could be adhered to as a new form of base money besides overnight deposits held in central banks and issued banknotes. Even though the definition of new currency type could be varying, the Bank of International Settlements (BIS, 2020) has shaped the path with the following principles: CBDC should be existing together with other types of money; it should not create any harm to financial or monetary stability and make a promotion for innovation and efficiency.

Since the introduction of the digital currency idea, researchers by scholars and economists have soured in many directions, especially, noting the fact that there is no historical precedent or experience. Currently society is in the midst of potential change and introduction of new type of money into day-to-day lives, where implications and real consequences are yet to be experienced. However, in order for the launch and implementation of this particular currency would be smooth and with capped risks, it is important to map and categorize already existing theoretical observations, suggestions, and ideas presented by researchers all around the world.

This paper aims to display a theoretical systematic review of central bank digital currency and its new approach in categorizing research streams based on the following life cycle of CBDC - motivation to issue, design features, prediction of demand, and impact on the financial system with challenges to be considered.

The literature review is displayed in Section 1, while the concise description of the methodology is present in Section 2. The systematic literature analysis is conducted in the following Section 3, while the conclusions are shown in Section 4.

Literature Review

Following the BIS Committee on Payment and Settlement Systems (2003), the contemporary monetary system is composed of three kinds of money:

- 1) cash (cash banknotes and coins issued by the central bank);
- 2) central bank reserves, which are composed of commercial banks' balances;
- 3) commercial bank deposits held by the private sector.

The principal difference between these kinds of money is their division into private and public money. It can be argued that a significant part of the population is exposed to 'rational inattention' and treat all money (e.g., physical cash, deposits in the bank) forms as the same (Penetta, 2021) and cannot identify any difference between private and public money complementary circulating in a dual monetary system. Public money is a so-called safe and risk-free form of money (for example - cash, and reserves held at the central bank) that is certified by the central bank and backed up by the State, its authority, strength, and credibility, thus as per Dow (2017), it carries on a very unlike possibility to get bankrupt. While other forms of money (for example – commercial bank deposits) are provided by private entities in the form of liability with exposure to default risk (Penetta, 2021), and following Brunnermeier and Niepelt (2019), the value of private money is coming from trust in the provider of that money and the assurance, that private money seen in an individual's current bank account could be converted into proportion one-to-one with public money (e.g., money in a bank account could be cashed out to banknotes or banknotes could be deposited in a bank account simultaneously while being a direct liability to a financial institution, where the current bank account is opened).

Based on the current payment landscape provided by The Global Findex Database (2022), society is conducting more payments via electronic means (i.e., using deposits held in commercial banks), while risk-free money (i.e., fiat cash) starts to fade into marginal notes, leaving central banks without a powerful monetary tool to fight the financial instability in the time of distress. Thus, the central bank's approach to the creation of a digital representation of public money is a valid point. Especially, bearing in mind this unity and interaction between private and public money summarized by the Bank of International Settlements (2003) – central bank money should not crowd out private operators as well private money should not take out the central bank money of the market, everything is for the sole purpose for a safe and efficient financial system with the singleness of currency.

Following the theory of central banking, central banks have control over price stability, and interest rates plus possess a monopoly for the money supply, its issuance, maintenance, and storage (Dow, 2017). Central banks as an overseer of their respectively assigned commercial banking system, right now are put at a crossroads: how to fight the increased usage of unregulated cryptocurrencies and how to maintain the reputation of respectable authority by not losing monetary sovereignty, when the usage of physical cash is decreasing. Thus, the issuance of a digital version of public money sounds like an attractive and treasured solution to stay up to the game. As the implementation of CBDC is still in the early stage, thus counting the merits and curses provided by CBDC

is quite challenging, especially when empirical data sources are in scarcity and most of the quantitative analyses are obtained via theoretical model simulations.

At the same time as with any launch of new investment product, the whole cycle such as motivation, design features, potential demand, arising risks, even at theoretical level should be adhered and evaluated. For example, Davoodalhosseini (2022) assumes that CBDC is costly for end-users as they should trade in anonymity to use it. Using simulation based on macroeconomic data taken from Canada and the United States, it could be concluded that preference for using cash or CBDC depends on costs: if costs are relatively small, then only CBDC should be used, while if costs are too high – cash only should be circulating in the economy. If costs are moderate, both instruments could be used in the economy, just both elements should not be treated as perfect substitutes for one another. As well, the pressure on a country's monetary policy could be made from foreign countries, as Ferrari-Minesso et al. (2022) suggest, if one country introduces CBDC, it creates asymmetry in the international monetary landscape and could reduce monetary policy autonomy in other countries or amplify the spillovers of shocks. Kochergin and Yangirova (2019) suggest that the largest impact on the monetary and credit system is made not only by the embedded features of CBDC but as well on how smoothly this digital instrument is integrated into the financial system.

Research Design

As CBDC is a relatively new subject and still in its early development, only with a few real-life examples to count on, while much more research in different countries is being thoroughly held and accessed. However, before any further and massive implementation of new means of payment, it is important to perform and gather already captured ideas by other scholars in order to draw benchmarks and highlight new areas, which would be worth exploring more from a theoretical point of view before any adverse effect would take place in the real world.

The authors have conducted a literature review on currently accessible scientific sources written about CBDC and made a systematic, comparative review using the basis of new categorization into four pillars – motivation to issue, diverse design features, potential assessment of demand, and finally, the prospective impact on the various areas in the financial system and challenges to be overcome.

Central Bank Digital Currency's impact on the financial system

As well, from a theoretical point of view, seeing the bigger picture and meticulously classifying different research streams is important for a consecutive and deep understanding of this new concept. Altogether, research in CBDC is souring in all directions and the author suggests a new way to classify currently available literature sources based on the whole value chain in CBDC:

- 1) factors leading to the issue of CBDC;
- 2) the potential design with the underlying technology;

- 3) prospective demand of society and benefits;
- 4) the possessed impact and risk for the financial system, its participants, and society in general.

The areas of current scientific literature about CBDC could be summarized in Figure 1 and will be further discussed in further sub-paragraphs.

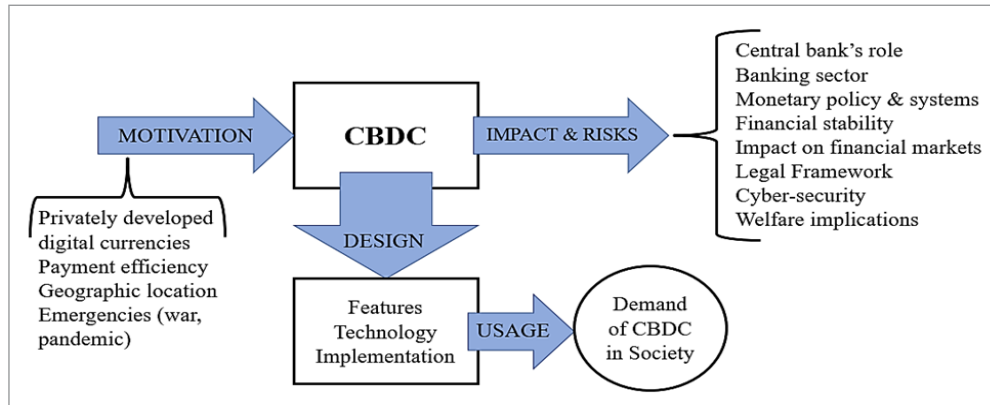


Figure 1. Main CBDC research areas

Source: prepared by the authors

Motivation to launch Central Bank Digital Currency

The first strand of the literature focuses on the origins of this new type of currency. With only encouragement that CBDC would provide the different possibility to use public money and desired cheap, rapid peer-to-peer transactions, the implementation would have not been moving so far without external factors. As Jonker et al. (2022) advise, the turbulent Covid-19 pandemic has accelerated the need to switch from physical cash to electronic payments (debit/credit cards, e-Wallets installed in smartphones) as it was believed that physical cash could transmit contagious pathogens. As well various legislative editions in different countries were passed to curb the movements of physical cash. For example in the Republic of Lithuania, according to the edition of the 3rd paragraph of Article 139 in the Labour Code (2022) that since the 1st of January 2022, an employee's monthly salary should be paid into the current bank's account held in the individual's name or recent amendment for the Law on Restrictions on Cash Transactions (2022), where the threshold for maximum payment in cash is set to 5000 euros.

Another node – cash and commercial bank deposits already experiencing the battle with cryptocurrencies and other types of private e-money. Sandner et al. (2020) discuss that the widely talked about case of Meta's stablecoin Diem (formerly known as *Libra*), caused many concerns from Governments and other regulatory bodies among various countries, as with almost 3 billion users around the globe¹, the private currency in the

¹ As per statistics of Q3 2022, 2,958 billion people were monthly active on Facebook (Data retrieved on 15th December 2022, from <https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/>)

social network could lead to easier adoption than it would be with for CBDCs and create unpredicted asymmetry in financial markets without any or very small control coming from regulator side. Even though it seemed that the project is progressing towards launch, as a consequence, Diem development was shut down at the beginning of 2022.

The third pillar - considering that in some parts of the world due to geographical, economic, and political reasons, there is a huge gap between people, who have no access to bank services (Oh & Zhang, 2022) or due to a lack of trust in commercial banks, chose not to be a part of a particular system. Technological advancement, active development in the privately issued cryptocurrency market, the decrease in using fiat cash, and moving towards electronic payment solutions provided by commercial banks, neo banks, and fintech companies are among the main reasons encouraging central banks to rethink the strategy on being able to ensure financial stability, robustness, and safety guarantee for society.

Some of the literature focuses on identifying the motivation behind launching CBDC which is closely related to the potential benefits offered by CBDC. From the point of view of financial institutions, Barontini and Holden (2019) surveyed 62 central banks around the world to identify that payment safety and domestic payments efficiency and financial safety are among the top choices in developed countries while developing countries are motivated by payment efficiency and potential higher financial inclusion. While a working group of central banks (2021) themselves, they identify motivations such as potentially improved resilience and financial inclusion with continuous access to central bank money, upgraded cross-border payments with fewer costs and a larger choice of payment methods in general. Supporting previously mentioned positivity, the main objectives and benefits of CBDC as per Edwards (2021) and Williamson (2022), are help in mitigating crime which is associated with cash plus the ability to offer interest payment and higher financial inclusion for poor or unbanked persons. According to Singh et al. (2022) based on input from 27 experts, the encouragement to launch CBDC in emerging markets could be categorized into 4 categories: payment-related, financial stability-related, monetary policy-related, security, and social motivations, where payment-related motivations could be described as the most significant ones.

However, behind various mentioned advancements, some concerns as well arise, because central banks and governments would retain a huge junk of personal data not only for good reasons, thus it is a two-sided coin. With a better ability to capture data in financial markets and quicker intervention in need using monetary policy, the government's ability to closely monitor financial activities could potentially overlap to some extent by invading the privacy and right to civil liberty of people (Oordt, 2022).

It could be summarized that motivations to launch CBDC are complex and polygonal, but this just highlights the importance of thoughtful discussion to see and clarify how the design features should be expressed while launching CBDC.

Demand and adoption of Central Bank Digital Currency

All wonderful innovations could remain locked and wasted if there would not any acceptance and eagerness from society to adopt those changes. CBDC as well must take

this test and find its place in financial systems. Integrated features in retail CBDC and implementation infrastructure is playing a key role in attracting potential end-users of this chain – the households. The household's specific determinants and habits in each country (progressive or still developing), their trust in issuing institutions and currency system (Soilen & Banhayoun, 2022), as well as a general willingness to adopt CBDC as a potential payment option play a vital role (Bindseil, 2019).

Maryaningsih et al. (2022) in their research have identified that wholesale CBDC is more popular around advanced economies, while retail CBDC is getting more attention in developing economies with larger informal economies and quite low financial inclusion, but they are accelerated by innovation capacity, a higher degree of openness and significant role by local authorities, while retail CBDC development in advanced economies are driven by moving to 'cashless' as less cash is used and development in financial markets. Talking about wholesale CBDC, cross-border transactions are the main driver here for both elements.

Consecutive and unavoidable change of generations could as well play a vital role, as millennials and subsequent generations adapt themselves to digital technologies and smart devices as being second nature, thus it could be anticipated that those generations would be among the first ones testing CBDC, while baby boomers might be more conservative and partial.

Nevertheless, shadow economy and user tax avoidance play a significant part in CBDC acceptance. The undertaking itself is varying, as in the developed Western countries, the informal/shadow economy is taking a diminutive part in the whole economy, thus the introduction of CBDC would not take a big challenge and could easily be widely adopted, while the same could not be drawn for developing countries. However, with incentives such as a tax reduction or offered positive interest rates, the adoption of CBDC could become at least a bit wider in developing countries as well (Oh & Zhang, 2022). Agur et al. (2022) add that households choose their payment method based on preferences, involved costs, convenience in using the payment system or the instrument itself, and if there are any incentives attached. So, it leads to the conclusion that CBDC should be somehow attractive to be accepted and used widely.

The attractiveness and demand for wholesale CBDC between the financial intermediaries and other institutions are apparent, but with retail CBDC it might not be so straightforward. From de facto examples, even if the rollout at the beginning seemed to be successful and promising, some South American countries have not experienced desired attraction and usage of CBDC. Ecuadorian CBDC called as 'Dinero electronico', which was denominated in the US dollar has not succeeded since at the moment of distribution (2014-2018) society was not ready to fully immerse itself into this innovation, let alone there was no possibility to use this currency for international payments and with a lack of monitoring, it could easily lead to criminal activity facilitation or surveillance program (Arauz et al. (2021). Additionally, Sarmiento (2022) pays attention to Uruguay and its endeavour in launching e-Peso, which eventually was as well cancelled, but provides a great deal of discussion on details that should be considered while launching CBDC as

security aspects and traceable transfers for easier overcoming on operational problems or reputational risk of CBDC issuing institution. As well, before engaging in producing CBDC, central banks try to predict or even survey the initial demand. For example, in the case of Denmark (2022), where the central bank put on hold the implementation of retail CBDC with an argument that demand would not be sufficient, and Danish citizens have plenty of solutions for payments available as Denmark is among the most digitalized countries in the world. Alonso et al. (2020) summarize the reasons for rejecting CBDC below:

- 1) Failed testing and a need to improve to provide more security;
- 2) Currently, existing electronic payment has more advantages than CBDC;
- 3) Lack of interest from society in the adoption;
- 4) Privately issued digital currencies are more attractive than CBDC.

In the countries where retail CBDC is still in the stage of research or early proof-of-concept testing, researchers in different countries have started to survey the end-users of CBDC (households) to measure the demand. However, it is easier said than done, because quite often the respondents are not aware of this new latent way of payment. Concluding conducted research on digital euro implementation in Germany, Tronnier et al. (2022) highlight, that the central bank should initiate sound promotion of CBDC benefits as a convenience, and creditability as a trustworthy means of payment, plus alleviate the concerns on privacy by offering suitable solutions for end-users. It could be debatable, but so far, the demand for retail CBDC could be determined by payment convenience and the ability to maximize private benefits for its users and if CBDC would be carrying on any incentives like an interest payment.

Design features of Central Bank Digital Currency

Delving further into the field of CBDC, it focuses on what potential design features this particular means of payment should be incorporating. In general, as with all innovations, there is an ambition that CBDC as a type of public money would outperform already existing digital currencies by offering more efficient and quality-driven services as well as encouraging the public to use more trusted means of digital payments. As well, the CBDC initiative by the central bank is not profit-driven. Morales-Resendiz et al. (2021) highlight that central banks should thoroughly evaluate the citizen's payment habits and domestic concerns both in regular times and in distress to create payment solutions with the potential to fulfil current gaps.

Firstly, as per Ferrari-Minesso et al. (2022), all CBDC development depends on where and in which venue it should be placed – if it should be accessible only for financial intermediaries and large institutions (wholesale CBDC or wCBDC) or it could be held and transferred by the general public (retail CBDC or rCBDC). As well, there is a possibility to create a universal one, to be used for both purposes. Moreover, Agur et al. (2022) advise that CBDC should have a similar feature as cash has – settlement happens with immediate finality - and even though CBDC exists only in electronic form, it should be ensured that it could be easily converted into cash.

Based on available scientific literature, it can be observed that retail CBDC development attracts much more attention from scholars than wholesale CBDC. The author thinks that the potential reason is due to its direct impact on the end users (households, firms) than wholesale CBDC. When developing retail CBDC, the central bank should be able to shape and design it in the way, it would be suitable because central banks are taking care of the money supply (the money supply itself is a very important factor in maintaining monetary policy) and foreign exchange (Dow, 2017). Agur et al. (2022) state, that CBDC as an instrument has a social value as it is possible to mix and match distinctive features coming from cash and deposits. The choice of CBDC design is driven by many varied factors. Mancini-Griffoli et al. (2018) divide the features of CBDC into two groups: fixed (acceptance as a fast payment solution, low settlement risk and costs) and flexible (interest, different stage of anonymity). Most of the authors (Borgonovo et al. (2021), Minesso et al. (2022), Chu et al. (2022)) agree that CBDC should cover at least these four basic features: anonymity, the ability to bear interest and act as a legal tender, and digitization-technology.

Privacy/anonymity: anonymity and universality are one of the most attractive features of physical cash as by using it peer-to-peer, there could be no trace of sight, while using the deposits for transfers in current bank accounts, we exchange not only money but as well expose much more data. Similar to the latter, CBDC is a fully traceable digital product. A human birthright to privacy is highly discussed among characteristics to be embedded into CBDC, as depending on how it would be attained could highly affect the demand for people using digital currency. Based on public consultation made by the European Central Bank (2021), two-thirds of respondents agree that financial intermediaries should incorporate the ability to access digital euro via their respective systems and digital currency should possess privacy (43% of respondents). As well Jabbar et al. (2023) conducted survey has displayed, the privacy attributes in CBDC play an important role and respondents were quite negative towards the disclosure of privacy, however, the opinion could be altered, if the benefits offered by CBDC (e.g. availability, convenience) would be greater than any other means of payment - then privacy could be traded away. However, even though regulations such as General Data Protection Regulation (GDPR) were introduced in the European Union in 2018, the concerns for what purpose personal data would be used are not blown out of proportion as from an international point of view, there is no uniformed global legislation, while corporations facilitate their activities all across the continents. Examples, like Borgonovo et al. (2021) provide - personal data that could be collected and used for commercial use (e.g., sold for customer profiling). While Rennie and Steele (2021) suggest that with an offered certain level of privacy (e.g., protecting users' data from third parties), would be a great competitive advantage towards currently existing electronic payment systems. Ongoing discussions of open banking/open finance concept likewise trigger the similar issue of privacy as CBDC. On the other hand, Wang et al. (2022) admit that without anonymity or with pseudo-anonymity, it would be easier and faster to track down illegal activities and money laundering, but in this case, criminals undoubtedly would not use CBDC as one of the primary ways for committing illicit activities.

Interest-bearing: as physical cash and its store of value function is impacted by inflation, to keep financial stability and control the money supply, a central bank is left with tools such as interest rates to curb inflation. Thus, now it is a perfect opportunity for central banks to create a suitable policy tool with embedded interest-bearing features. This type of CBDC should be apparent in comparison to already existing means of payment to attract attention, while optimally built CBDC with interest-bearing could maintain the current financial ecosystem, not causing chaos (Agur et al. (2022); Wilkins (2022)). However, the attached interest rate to CBDC does not necessarily need to be only positive. Depending on arising economic situation and household output elasticity for consumption, central bank could apply a negative interest rate, which could help to regulate the monetary stability (Wang & Hausken, 2022). Moreover, the interest rate could be used as an incentive, to gain trust and acknowledgement from society.

Indeed, the Sand dollar is built without an interest-bearing feature, but there are some limits to how much CBDC can be transacted and held (Central Bank of Bahamas, 2022), while according to Mancini-Griffoli et al. (2018), it seems that none of central banks is considering to add this feature, for example, Reserve Bank of New Zealand propounds that direct fungibility should be applicable for CBDC; however, this opinion might change at the later stage.

Regulatory acceptance as a legal tender: it could be thought, that since CBDC would be issued by the central bank, it would automatically gain the legal tender status as cash has. However, in most countries, the legal framework for CBDC is absent and it has to be established with respective amendments in laws, considering whether CBDC is token-based or account-based as from a legal point of view it is quite a different concept (Bossu, et al., 2020). As well, the regulatory basis should be strengthened to avoid situations, where CBDC could be used for example to escape applied sanctions or break customer protection. As well, with the introduction of CBDC is not only central bank laws, but as well involves tax laws and privacy laws. Moreover, Teichmann and Falker (2020) advocate that a robust legal framework should be established, as well as invoking the importance for the international community to keep an eye on countries that could potentially violate human rights via CBDC and put relevant sanctions on them.

Digitization and technology choice: Technologic advancement in the last couple of decades created many more various possibilities and ways for CBDC to be introduced. The choice of the base technology of CBDC is still debatable, however, as per Zhang & Huang (2022), central banks should aim to use the most efficient and mature technology behind CBDC. From using account-based or token-based systems to building the underlying framework based on Distributed ledger technology (DLT), blockchain or conventional technology with various variations, each country makes the best suitable solution for their market. Kochergin and Yangirova (2019) highlight the difference between token-based and account-based authorization, where token-based CBDC is exposed to a problem in double-spending and electronic counterfeiting, while account-based CBDC would experience risks of identity thefts, nevertheless, from a practical point of view, token-based CBDC for retail payments while account-based CBDC could be used for wholesale payments.

Blockchain itself offers many benefits such as decentralization, transparency, security, and efficiency (Ozili, 2022). Transactions there are validated and recorded only after confirmation by other nodes, so it can assure that the records in the system should not be compromised. There are three kinds of blockchain: public blockchain, consortium blockchain and private blockchain. If central banks opt out of DLT technology, besides some challenges such as scalability, cross-chain interoperability, and performance, permissioned blockchain would be a better choice than the permissionless blockchain (Zhang & Huang, 2022). Despite the choice of the base technology for CBDC, it should be built in a way for easier integration with current payment infrastructure to provide traceable, verifiable, and consistent services, if it is expected that CBDC would be used as a supplementary part of transactions (Lee et al. (2021).

While developing infrastructure, consultations with regulatory bodies are important and as Renwick and Gleasure (2020) advise, their participation is vital to set protocols and rulesets right from the beginning, otherwise issues arising after the launch of CBDC will have no possibility to be amended or would cost additional investment. Plus, even though there is a wish to maintain centralized control, the digitization process should be properly enforced to prevent double-spending of money, and reduce the resources spent on routine and simple tasks such as monitoring transactions to ensure a decent audit trail (Ozili, 2022). However, due to CBDC's complexity in both possible risks and advantages, the delicate balance via technical design should be reached as well considering that possible implementation costs would be worthy of upcoming benefits (Allen, et al., 2020). Moreover, due to the possibility of power outages, natural disasters, or wars, the technical possibility to access CBDC offline should also be adhered to. But so far, a framework for offline payments is not implemented and issues with security requirements are still ongoing (Chu et al. (2022).

Nevertheless, other design features for CBDC should be as well conceded, as Mineso et al. (2022) argue that differently expressed features in CBDC could have various effects on household welfare. Based on a Canadian market survey, Li (2022) adds that CBDC's ability to bundle bank services and provide a rate of return are among the most common responses. Other researchers, such as Yao (2019) suggest that forward contingencies (time, sector, loan rate, economic state) should be implemented while launching CBDC as it could help to regulate monetary policy in real-time, and track money supply and circulation. Keister and Sanches (2022) suggest that there could be distinct types of CBDC by different target market areas: CBDC competes only with cash (cash-like CBDC) or CBDC competes with commercial bank deposits (deposit-like CBDC) or universal CBDC. However, it would be quite technologically complicated to create and maintain a few different CBDCs targeting one area within one central bank system, thus universal CBDC seems as the most viable option.

At the same time, political traditions, national culture, and values could also play a decisive role in CBDC's design and eventually impact the demand of the nation. As Luu et al. (2022) have concluded, cultures with strong roots in traditions, strict social and gender rules as well with high acceptance of inequality in society, are more willing and working

towards implementing CBDC, while countries that value safety and try to avoid arising uncertainties so far are less involved in CBDC. Koziuk and Ivashuk (2022), and Sarmiento (2022) as well add, that for example, cultural determinants such as hierarchies, equality, and individualism could affect the choice of design for anonymity/privacy elements in CBDC.

There is no ‘one-size fits all’ concept in the matter of CBDC, thus it could be expected to see tailored CBDCs for each country and its economy but containing an unspoken vital component as with cash – trust in it and its issuing institution. Latent design choices for CBDC could be summarized in Table 1.

Table 1. Design choices for CBDC

Feature	Choice	Explanation
Accessibility	Retail versus Wholesale	<i>Wholesale CBDC</i> – refers to exchange only between commercial banks and central banks; <i>Retail CBDC</i> – general population could be using it However, as Bossu et al. (2020), a few central banks contemplate general/universal purpose CBDC to be used on both venues
Authorization	Account-based versus token-based	<i>Account-based</i> (setup is like what we currently have with bank accounts, where it is required to verify the identity of the payer, with no anonymity) <i>Token-based</i> (this would be built on DLT or blockchain, i.e., it would be required to check the validity of the object, which would be used as a payment, partial or full-anonymity)
Transfer mechanism	Transactions are managed via the central bank (i.e., centralized) versus via the DLT system (decentralized)	Ledger structure could be: <ul style="list-style-type: none"> • Centralized (central bank or other assigned organization manages and regulates the transactions) and somehow like currently existing systems RTGS; • Decentralized (via DLT, where transactions happen peer-to-peer). There are two types of DLT: Licensed DLT and Unlicensed DLT
Interest	Bearing interest versus non-bearing	CBDC could be designed to bear positive or negative interest (potential central bank’s usage as a tool for monetary policy implementation) CBDC maintains the same specifics as cash – no interest-bearing feature.
Anonymity	Full confidentiality vs pseudo-anonymity or no anonymity at all	This feature attracts most attention due to privacy concerns, as even with full anonymity, the transaction made using CBDC leaves the traces in the systems into the big contrast to physical cash
Wrapper	Physical card versus digital wallet	Central banks debate whether there should be a digital wallet, or whether it would be better to have physical cards due to network connectivity or digital illiteracy
Exchange rate	Cash to CBDC converted on 1:1 base vs different proportion	Kumhof and Noone (2021) suggest that not necessarily commercial bank deposits should be exchanged at par into CBDC. The different proportion could be for example used as an incentive to attract users

Feature	Choice	Explanation
Restrictions for usage	Restricted usage versus no restrictions applicable	CBDC could be used for any purpose, or it could have some restrictions for certain payments and etc.
Claims and Transaction records	1) Direct 2) Hybrid 3) Indirect (synthetic)	<i>Direct</i> CBDC – issued and regulated by central bank. <i>Indirect (synthetic)</i> CBDC – issued and taken care by commercial banks <i>Hybrid CBDC</i> – the claim of CBDC would still be directly against the central bank, but all customer-facing business is managed by intermediary.
CBDC introduction manner into the market	CBDC quantity rule versus the CBDC interest rate rule.	As per Kumhof and Noone (2021), CBDC quantity rule could be explained in the way when central banks decide on how much CBDC should be issued and leaves interest rate to adjust, while CBDC interest rule stands when central bank decides on how much interest CBDC should bear and the quantity of CBDC would adjust in the economy.
CBDC competition	CBDC target area (deposits or cash)	CBDC competes with cash and deposits separately (target CBDC) or CBDC competes with both (universal CBDC)

Source: prepared by the authors using (Chu, et al., 2022), Agur et al. (2022), (Kumhof & Noone, 2021)

Central Bank Digital Currency's impact on the financial system and arising challenges

By initiating the launch of new type of payment, each central bank or other authorized entity in designated country has not only access and understand its motivation, desired design, and likely demand from population, however, the simultaneously the health and strength of country's financial system should be adhered as well. The author has gathered the summary of various challenges and its types, which are present in the *Table 2* and were partially discussed in the above paragraphs, but some additional supporting information would be present here accordingly.

From economic and banking point of view, Adrian and Mancini-Griffoli (2021), Meaning et al. (2018), and Tronnier et al. (2022) urge to closely monitor the banking sector to avoid structural disintermediation and pay attention to financial stability and consumer protection, while Bindseil (2019) underlines different approaches how CBDC could cause troubles with financial cycles. Conversely, Brunnermeier and Landau (2022) estimate that the circulation volume of retail CBDCs should not be over the odds, thus authors postulate that the negative effect on the banking system would be relatively trivial. Either way and indisputably, with CBDC launch commercial banks would experience additional costs due to the need to upgrade in-house software, and the entity's internal procedures, as well as investing time in raising the competence of their employees.

Table 2. Potential challenges for CBDC

Challenge type	Challenge Sub-type
Legal	Accepting CBDC as official means of payment or legal tender
	Privacy/anonymity challenge
	Central Bank Law, Monetary Law, Cybersecurity Law, Data Security Law, Personal Protection Law
	Compliance and monitoring of CBDC
Economic	Effect on monetary policy
	Effect on financial stability
	Effect on commercial banks and other financial institutions
	Effect on central banks
	Effect on payment system in general
	The reputation of the central bank
	Tax evasion
	Transaction costs
	Usage of CBDC as derivative
	Price stability / inflation targeting
Cross-border payments	
Environmental	Energy consumption
	Sustainability focus
Technological	Cybersecurity risk
	Infrastructure
	Technology choice
	Design choice
Other	Trust and acceptance in society
	Operational costs
	Marketing (mass media, social networks)

Source: prepared by the authors summarizing multiple sources

One of the important pillar influenced by the CBDC's launch is the stability of the monetary system and monetary policy. Bordo and Levin (2017) argue, that to build a framework for essential price-level targeting instead inflation targeting, CBDC itself should be account-based and interest-bearing. While optimal monetary policy could depend as well on how cash and CBDC are being distributed in the economy. Moreover, as CBDC has gained significant traction from regulatory bodies and financial institutions due to its potential benefits and technical possibilities to even outperform some already existing privately issued digital currencies. However, in the prevention of errors, certain lines should be drawn as well. Morgan (2022) suggests that for CBDC would be able

to avert the problems associated with stablecoin, governing bodies should be urging the adoption of needed regulation towards both the latter and the underlying case for CBDC. For example, without properly drafted legislation, users can hold CBDC permanently and during financial turmoil could crowd out bank deposits (Williamson, 2022). As well, the research based on the digital euro area dictates that there should be some regulatory adjustments to the Treaty on the Functioning of the European Union as following the articles, the digital euro should not bearing-interest, as well itself CBDC is not identified as a medium of monetary policy (Zellweger-Gutknecht et al., (2021). Simultaneously, authors such as Morales-Resendiz et al. (2021) advocate for joint central bank and private sector cooperation as both sides have different expertise and experience, which could lead to the successful launch of CBDC in the best possible outcome for society and easier integration in the already existing financial landscape. Plus, it would keep both parties (private and public sectors) in check and accountable to one another.

As well, emerging countries would benefit from the implementation of stronger regulations, which could reduce tax avoidance, and reflects the full transparency for income of end-users (Edwards, 2021). As per Kelmanson et al. (2019), emerging countries are plagued by an informal economy of the size consisting of around 30-35% of GDP, while advanced countries possess an average of 15-20% of GDP, thus based on this information there is a room for CBDC to increase welfare.

Even though there is much discussion about CBDC features such as the technology of issue, place of storage, transfer mechanism, and restrictions on availability, various authors try to assess digital currency's significance and importance for financial markets. With a constructed CBDC's signal index, the capital market in the fintech sector positively reacts to CBDC signals, however, with time the sensibility reduces as market expectations raised for fintech play a role in CBDC development continues to be stable (Li et al. (2022).

A few pieces of research have been conducted in the tourism sector, as with increasing numbers of people affording to travel, real-time and reliable international payments are becoming more of a necessity to be implemented. As Auer et al. (2021) state, central banks themselves are interested to offer convenient global payment services and CBDC could play a significant role. While a few surveys were conducted to check if CBDC would be used among international tourists. Kim et al. (2022) identified that awareness of CBDC as an innovation is a very important part of the order CBDC would be accepted as a payment method in the hospitality sector. While Radic et al. (2022) surveyed international tourists from China, Korea, and the United States to measure their willingness in using CBDC and what external factors could trigger more active usage - based on the survey, the most significant one was the impact coming from mass media. Thus, by evaluating the importance of social networks and mass media as an influential power, central banks should as well think about effective communication and advertising campaign to create wide public support and trust in CBDC payments.

As well, it has to be underlined that social networks and mass media could play a considerable role in influencing financial markets. By constructing two new indexes – the CBDC Uncertainty index (CBDCUI) and CBDC Attention Index (CBDCAI) - Wang et al.

(2022) display, how CBDC news published via media could influence certain volatilities in the financial market: significant positive effect for foreign exchange, bond, and cryptocurrency markets, as well commodities (gold), but on the contrary negative effect is posed on the stock market. As well an operation model for business could be affected. Ding et al. (2022) examine the impact of CBDC volatility in Supply Chain Management (SCM) for manufacturing companies, and the authors conclude that volatility has a considerable effect thus the stable operation of CBDC is crucial to provide benefits.

As CBDC is not yet implemented, it is hard to evaluate the impact of Anti-Money Laundering (AML) and Counter-Terrorist Financing (CTF) procedure changes as well it is not yet fully clear to which extent the privacy feature would be a trade-off in CBDC. But Dupuis et al. (2022) agree that CBDC introduction would have negligible impact on AML activities, but more in general it would have just a new shiny venue besides physical cash and cryptocurrencies for cybercriminals. Furthermore, the applicable cybersecurity, privacy laws have to be amended. Just to highlight, CBDC could have an impact on sustainability and the environmental, social and governance (ESG) part. Laboure et al. (2021) suggest a lot of energy would be consumed during the production, transaction recording, and maintenance of CBDC, which leads to higher environmental pollution due to CO² emissions. But with advancement of technologies and taking into account remaining costs to maintain physical cash and coins as well, it could be believed that digital currencies could be the future.

Conclusion

The rapid development in technologies during the last couple of decades urges to move towards unavoidable changes in the financial landscape and payment methods, as even though society wants to have a safe and trustful store of value, means of payment and medium of exchange. On the other hand, the end-users of money expect to see improvements in terms of speed, reliability, convenience and accessibility of various methods of payment, thus both authorities and financial institutions should follow the tendencies and keep attractive for its users.

While comparing and systemizing currently available scientific research, the authors offer a new way to arrange currently available literature for Central Bank Digital Currency (CBDC), with the concept following the process of end-to-end in product life-cycle. This novel suggestion of dividing research areas comes into four different groups: motivations, design features, demands and final impact on monetary sovereignty and financial system as a whole. As most of the scholars delve into different spheres of this peculiar digital currency, it is important to keep overall overview in order to understand unclear areas and connections between different four mentioned pillars.

Central Bank Digital Currency is a complex issue with both rewarding benefits such as increased welfare and faster, safer transmission and burdensome challenges radiating out with far-reaching impacts beyond the financial sector of each country engaging in CBDC's development. With further actual expansion of CBDC and potentially more up-

coming releases or trial versions, we should be mindful, that all theoretical implications are based on historical data, thus even though a history has tendency of repetitiveness - it not necessary means, that currently suggested ideas on design, or assumed demand of society would remain constant and halted. Consequently, it leads to the idea, that CBDC itself should be constructed in a way, which could be easily transformed and adapted based on circumstances. As well, any sharp twists with CBDC are possible as due to the unknown adoption level and while seeking better management of financial stability, the introduction of CBDC could be creating important shifts in the financial ecosystem and break commonly known rules in the banking system.

References

1. Adrian, T., & Mancini-Griffoli, T. (2021). The Rise of Digital Money. *Annual Review of Financial Economics*, 13, 57-77. doi:10.1146/annurev-financial-101620-063859
2. Agur, I., Ari, A., & Dell’Ariccia, G. (2022). Designing central bank digital currencies. *Journal of Monetary Economics*, 125, 62-79. doi:10.1016/j.jmoneco.2021.05.002
3. Allen, S., Čapkun, S., Eyal, I., Fanti, G., Ford, B. A., Grimmelmann, J., Juels, A., Kostiainen, K., Meiklejohn, S., Miller, A., Prasad, E., Wüst Zhang, K., F. (2020). Design Choices for Central Bank Digital Currency: Policy and Technical Considerations. *National Bureau of Economic Research. Working paper No. 27634*, 1-89. doi:10.3386/w27634
4. Alonso, S., Fernandez, M., Bas, D., & Kaczmarek, J. (2020). Reasons Fostering or Discouraging the Implementation of Central Bank-Backed Digital Currency: A Review. *Economics*, 8(2), 1-27. doi:10.3390/economics8020041
5. Arauz, A., Garratt, R., & Ramos F., D. F. (2021). Dinero Electronico: The Rise and fall of Ecuador’s central bank digital currency. *Latin American Journal of Central Banking*, 2(2), 1-10. doi:10.1016/j.latchb.2021.100030
6. Auer, R., Haene, P., & Holden, H. (2021). Multi-CBDC arrangements and the future of cross-border payments. *BIS Papers*, pp. 1-23. Retrieved November 23, 2022, from <https://www.bis.org/publ/bppdf/bispap115.htm>
7. Bank of International Settlements. (2003). *The role of central bank money in payment systems*. Retrieved December 14, 2022, from Bank of International Settlements: <https://www.bis.org/cpmi/publ/d55.pdf>
8. Barontini, C., & Holden, H. (2019). *Proceeding with Caution - A survey on Central Bank Digital Currency*. Retrieved November 25, 2022, from Bank of International Settlements: <https://www.bis.org/publ/bppdf/bispap101.htm>
9. Bindseil, U. (2019). Central Bank Digital currency: financial system implications and control. *International Journal of Political Economy*, 48(4), 303-335. doi:10.1080/08911916.2019.1693160
10. BIS. (2020). *Central bank digital currencies: foundational principles and core features*. Retrieved December 28, 2022, from Bank of International Settlements: <https://www.bis.org/publ/othp33.htm>
11. Bordo, M. D., & Levin, A. T. (2017). Central Bank Digital Currency and the Future of Monetary Policy. *National Bureau of Economic Research, Working paper No. 23711*. doi:10.3386/w23711
12. Borgonovo, E., Caselli, S., Cillo, A., Masciandaro, D., & Rabitti, G. (2021). Money, privacy, anonymity: what do experiments tell us? *Journal of Financial Stability*, 56, 1-26. doi:10.1016/j.jfs.2021.100934
13. Bossu, W., Itatani, M., Margulis, C., Rossi, A., Weenink, H., & Yoshinaga, A. (2020). *Legal Aspects of Central Bank Digital Currency: Central Bank and Monetary Law Considerations*. Retrieved November 26, 2022, from International Monetary Fund: <https://www.imf.org/en/Publications/WP/Issues/2020/11/20/Legal-Aspects-of-Central-Bank-Digital-Currency-Central-Bank-and-Monetary-Law-Considerations-49827>

14. Brunnermeier, M. K., & Niepelt, D. (2019). On the equivalence of private and public money. *Journal of Monetary Economics*, 106, 27-41. doi:10.1016/j.jmoneco.2019.07.004
15. Brunnermeier, M., & Landau, J.-P. (2022). *The digital euro: policy implications and perspectives*. Retrieved December 28, 2022, from European Parliament: [https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU\(2022\)703337](https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2022)703337)
16. Central Bank of Bahamas. (2022). *SandDollar*. Retrieved December 10, 2022, from <https://www.sand-dollar.bs/about>
17. Chu, Y., Lee, J., Kim, S., Kim, H., Yoon, Y., & Chung, H. (2022). Review of Offline Payment Function of CBDC considering security requirements. *Applied sciences*, 12(9), 1-28. doi:10.3390/app12094488
18. Committee on Payment and Settlement Systems. (2003). *The Role of Central Bank Money in Payment Systems*. Retrieved November 15, 2022, from The Bank of International Settlements: <https://www.bis.org/cpmi/publ/d55.pdf>
19. Danmarks Nationalbank. (2022). *New types of digital money*. Retrieved December 5, 2022, from Danmarks Nationalbank: https://www.nationalbanken.dk/en/publications/Documents/2022/06/ANALYSIS_no%208_New%20types%20of%20digital%20money.pdf
20. Davoodalhosseini, S. M. (2022). Central bank digital currency and monetary policy. *Journal of Economic Dynamics and Control*, 142, 1-22. doi:10.1016/j.jedc.2021.104150
21. Ding, S., Cu, T., Wu, X., & Du, M. (2022). Supply chain management based on volatility clustering: The effect of CBDC volatility. *Research in International Business and Finance*, 62, 1-14. doi:10.1016/j.ribaf.2022.101690
22. Dow, S. (2017). Central banking in the twenty-first century. *Cambridge Journal of Economics*, 41, 1539-1557. doi:10.1093/cje/bex051
23. Dupuis, D., Gleason, K., & Wang, Z. (2022). Money laundering in a CBDC world: a game of cats and mice. *Journal of Financial Crime*, 29, 171-184. doi:10.1108/JFC-02-2021-0035
24. Edwards, S. (2021). Central Bank Digital Currencies and the Emerging Markets: The Currency Substitution Challenge. *Challenge*, 64(5-6), 413-424. doi:10.1080/05775132.2021.2004738
25. European Central Bank. (2021). *ECB publishes the results of the public consultation on a digital euro*. Retrieved December 17, 2022, from European Central Bank: <https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210414-ca3013c852.en.html>
26. Ferrari-Minesso, M., Mehl, A., & Stracca, L. (2022). Central bank digital currency in an open economy. *Journal of Monetary Economics*, 124, 54-68. doi:10.1016/j.jmoneco.2022.02.001
27. Group of Central Banks. (2021). *Central bank digital currencies: system design and interoperability*. Retrieved December 5, 2022, from Bank of International Settlements: https://www.bis.org/publ/othp42_system_design.pdf
28. Yao, Q. (2019). Central Bank Digital Currency: optimization of the currency system and its issuance design. *China Economic Journal*, 12(1), 1-15. doi:10.1080/17538963.2018.1560526
29. Jabbar, A., Geebren, A., Hussain, Z., Dani, S., & Ul-Durar, S. (2023). Investigating individual privacy within CBDC: A privacy calculus perspective. *Research in International Business and Finance*, 64, 1-12. doi:10.1016/j.ribaf.2022.101826
30. Jonker, N., van der Crujssen, C., Bijlsma, M., & Bolt, W. (2022). Pandemic payment patterns. *Journal of Banking & Finance*, 143, 1-25. doi:10.1016/j.jbankfin.2022.106593
31. Keister, T., & Sanches, D. (2022). Should Central Banks Issue Digital Currency? *The Review of Economic Studies*, 1-28. doi:10.1093/restud/rdac017
32. Kelmanson, B., Kirabaeva, K., Medina, L., & Weiss, J. (2019). Explaining the Shadow Economy in Europe: Size, Causes and Policy Options. *IMF Working Papers*, 2019(278), 1-29. doi:10.5089/9781513520698.001
33. Kiff, J., Alwazir, J., Davidovic, S., Farias, A., Khan, A., Khiaonarong, T., . . . Zhou, P. (2020, June 26). *A survey of Research on Retail Central Bank Digital Currency*. Retrieved December 10, 2022, from

- International Monetary Fund: <https://www.imf.org/en/Publications/WP/Issues/2020/06/26/A-Survey-of-Research-on-Retail-Central-Bank-Digital-Currency-49517>
34. Kim, J. J., Radic, A., Chua, B.-L., & Koo, B. (2022). Digital currency and payment innovation in the hospitality and tourism industry. *International Journal of Hospitality Management*, 1-11. doi:10.1016/j.ijhm.2022.103314
 35. Kochergin, D., & Yangirova, A. I. (2019). Central bank Digital Currencies: Key Characteristics and Directions of Influence on Monetary and Credit and Payment Systems. *Finance Theory and Practice*, 23(4), 80-98. doi:10.26794/2587-5671-2019-23-4-80-98
 36. Koziuk, V., & Ivashuk, Y. (2022). Does it Matter for CBDC Design? Privacy-Anonymity Preferences from the Side of Hierarchies and Egalitarian Cultural Patterns. *Economics*, 10(1), 35-53. doi:10.2478/eoik-2022-0008
 37. Kumhof, M., & Noone, C. (2021). Central bank digital currencies - design principles for financial stability. *Economic Analysis and Policy*, 71, 553-572. doi:10.1016/j.eap.2021.06.012
 38. Labour Code. (2022). *Lietuvos Respublikos Darbo Kodekso patvirtinimo, įsigaliojimo ir įgyvendinimo įstatymas*. Retrieved November 20, 2022, from Teisės aktų registras: <https://www.e-tar.lt/portal/lt/legalAct/f6d686707e7011e6b969d7ae07280e89/asr>
 39. Laboure, M., Muller, M. H., Heinz, G., Singh, S., & Kohling, S. (2021). Cryptocurrencies and CBDC: The Route Ahead. *Global Policy*, 12(5), 663-676. doi:10.1111/1758-5899.13017
 40. Lee, D. K., Yan, L., & Wang, Y. (2021). A global perspective on central bank digital currency. *China Economic Journal*, 14(1), 52-66. doi:10.1080/17538963.2020.1870279
 41. Li, J. (2022). Predicting the Demand for Central Bank Digital Currency: A structural analysis with survey data. *Journal of Monetary Economics*, 1-23. doi:10.1016/j.jmoneco.2022.11.007
 42. Li, Z., Yang, C., & Huang, Z. (2022). How does the fintech sector react to signals from central bank digital currencies. *Finance Research Letters*, 50, 1-5. doi:10.1016/j.frl.2022.103308
 43. Luu, H. N., Do, D. D., Pham, T., Ho, V. X., & Dinh, Q.-A. (2022). Cultural values and the adoption of central bank digital currency. *Applied Economics Letters*, 1-7. doi:10.1080/13504851.2022.2089342
 44. Mancini-Griffoli, T., Martinez-Peria, M., Agur, I., Ari, A., Kiff, J., Popescu, A., & Rochon, C. (2018). *Casting Light on Central Bank Digital Currencies*. Retrieved December 19, 2022, from International Monetary Fund: <https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2018/11/13/Casting-Light-on-Central-Bank-Digital-Currencies-46233>
 45. Maryaningsih, N., Nazara, S., Kacaribu, F., & Juhro, S. (2022). Central Bank Digital Currency: what factors determine its adoption? *Bulletin of Monetary Economics and Banking*, 25(1), 1-24. doi:10.21098/bemp.v25i1.1979
 46. Meaning, J., Dyson, B., Barker, J., & Clayton, E. (2018). Broadening Narrow Money: Monetary Policy with a Central Bank Digital Currency. *Bank of England Working Paper No. 724*, 1-36. doi:10.2139/ssrn.3180720
 47. Morales-Resendiz, R., Ponce, J., Picardo, P., Velasco, A., Chen, B., Leon, S., . . . Hodge, A. (2021). Implementing a retail CBDC: Lessons learned and key insights. *Latin American Journal of Central Banking*, 2(1), 1-10. doi:10.1016/j.latecb.2021.100022
 48. Morgan, J. (2022). Systemic stablecoin and the defensive case for Central Bank Digital Currency: a critique of the Bank of England's framing. *Research in International Business and Finance*, 62, 1-7. doi:10.1016/j.ribaf.2022.101716
 49. Oh, E. Y., & Zhang, S. (2022). Informal economy and central bank digital currency. *Economic Inquiry*, 60(4), 1520-1539. doi:10.1111/ecin.13105
 50. Oordt, M. R. (2022). Discussion of "Central bank digital currency: Stability and information". *Journal of Economic Dynamics and Control*, 142, 1-4. doi:10.1016/j.jedc.2022.104503
 51. Ozili, P. K. (2022). Central bank digital currency research around the world: a review of literature. *Journal of Money Laundering Control, Vol. ahead-of-print*, 1-20. doi:10.1108/JMLC-11-2021-0126

52. Penetta, F. (2021, December 13). *The present and future of money in the digital age*. Retrieved December 6, 2022, from Bank of International Settlements: <https://www.bis.org/review/r211213.htm>
53. Radic, A., Quan, W., Koo, B., Chua, B.-L., Kim, J. J., & Han, H. (2022). Central Bank digital currency as a payment method for tourists: application of the theory of planned behavior to digital Yuan/Won/Dollar choice. *Journal of Travel & Tourism Marketing*, 39(2), 152-172. doi:10.1080/10548408.2022.2061677
54. Rennie, E., & Steele, S. (2021). Privacy and Emergency Payments in a Pandemic: How to Think about Privacy and a Central Bank Digital Currency. *Law, Technology and Humans*, 3(1), 6-17. doi:10.5204/lthj.1745.
55. Renwick, R., & Gleasure, R. (2020). Those who control the code control the rules: How different perspectives of privacy are being written into the code of blockchain systems. *Journal of Information Technology*, 36(1). doi:10.1177/026839622094440
56. Sandner, P., Gross, J., Grale, L., & Schoulden, P. (2020). *The Digital Programmable Euro, Libra and CBDC: Implications for European Banks*. Retrieved from SSRN: <http://dx.doi.org/10.2139/ssrn.3663142>
57. Sarmiento, A. (2022). Seven lessons from the e-Peso pilot plan: The possibility of a Central Bank Digital currency. *Latin American Journal of Central Banking*, 3(2), 1-7. doi:10.1016/j.latcb.2022.100062
58. Seimas, L. R. (2022). *Teisės aktų registras*. Retrieved November 22, 2022, from Lietuvos Respublikos atsiskaitymų grynaisiais pinigais ribojimo įstatymas: <https://www.e-tar.lt/portal/lt/legalAct/d7206ef0df-d311ec8fa7d02a65c371ad>
59. Singh, S., Gupta, S., Kaur, S., Sapra, S., Kumar, V., & Sharma, M. (2022). The quest for CBDC: indentifying and prioritising the motivations for launching central bank digital currencies in emerging countries. *Quality & Quantity*, 1-16. doi:10.1007/s11135-022-01558-8
60. Soilen, K. S., & Banhayoun, L. (2022). Household acceptance of central bank digital currency: the role of institutional trust. *International Journal of Bank Marketing*, 40, 172-196. doi:10.1108/IJBM-04-2021-0156
61. Teichmann, F., & Falker, M.-C. (2020). Will digital currencies replace cash? Digital currency, privacy and surveillance. *Compliance Elliance Journal*, 6(1), 51-73. Retrieved December 27, 2022, from <https://cej-online.com/2020-vol-06-no-01-compliance-in-unprecedented-times/#56>
62. The Global Findex Database. (2022, July 7). *The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of Covid-19*. Retrieved November 18, 2022, from The World Bank: <https://www.worldbank.org/en/publication/globalfindex>
63. Tronnier, F., Harborth, D., & Hamm, P. (2022). Investigating privacy concerns and trust in the digital Euro in Germany. *Electronic Commerce Research and Applications*, 53, pp. 1-13. doi:10.1016/j.elerap.2022.101158
64. Wang, G., & Hausken, K. (2022). A game between central banks and households involving central bank digital currencies, other digital currencies and negative interest rates. *Cogent Economics & Finance*, 10(1), 1-23. doi:10.1080/23322039.2022.2114178
65. Wang, Y., Lucey, B. M., Vigne, S. A., & Yarovaya, L. (2022). The Effects of Central Bank Digital Currencies News on Financial Markets. *Technological Forecasting and Social Change*, 180, 1-39. doi:10.1016/j.techfore.2022.121715
66. Wilkins, C. A. (2022). Discussion of “designing central bank digital currency” by Agur, Ari and Dell’Ariccia. *Journal of Monetary Economics*, 125, 80-84. doi:10.1016/j.jmoneco.2021.09.009
67. Williamson, S. D. (2022). Central bank digital currency and flight to safety. *Journal of Economic Dynamics and Control*, 142, 1-25. doi:10.1016/j.jedc.2021.104146
68. Zellweger-Gutknecht, C., Geva, B., & Grunewald, S. N. (2021). Digital Euro, Monetary Objects and Price Stability: a Legal Analysis. *Journal of Financial Regulation*, 7(2), 284s-318. doi:10.1093/jfr/fjab009
69. Zhang, T., & Huang, Z. (2022). Blockchain and central bank digital currency. *ICT Express*, 8(2), 264-270. doi:10.1016/j.icte.2021.09.014