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What we know on Central Bank Digital Currencies (so far)

by Shalva Mkhatriashvili and Wim Boonstra

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National Bank of Georgia

What we know on Central Bank Digital Currencies (so far) *

Shalva Mkhatriashvili [†] and Wim Boonstra [⊗]

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Abstract

A central bank digital currency (CBDC) is a topic that is only going to gain importance as a couple of nations have recently went live with a retail CBDC system, dozens of them are piloting it and there are even more who actively research the topic. In the process, many studies have already identified several important potential benefits of a CBDC as well as potential risks and costs. As is already well understood, a CBDC introduction can have a profound impact on all three monetary policy, financial stability and payment systems. This paper, trying to be a go-to starting point for those just exposed to the topic, thoroughly reviews all the benefits and risks/costs associated with a CBDC in the current literature as well as underlines key areas of this topic that need more research. In addition, we try to lay some ground for systematizing three-dimensional linkages between benefits, costs/risks and design choices by (i) discussing probable design choices needed for each item in the list of benefits and costs/risks to-be-mitigated and (ii) overviewing what other benefits and cost/risk-mitigation aims these design choices may be in conflict with.

JEL Codes: E42, E50, G20

Keywords: Central bank digital currencies, monetary policy, financial stability, payment systems

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Contents

- 1. Introduction 4**
- 2. Design principles..... 6**
 - 2.1. Degree of anonymity..... 8
 - 2.2. (De)centralization 9
 - 2.3. Retail VS wholesale 12
 - 2.4. Remuneration 13
 - 2.5. Direct VS indirect/hybrid 13
 - 2.6. Quantitative limits 14
 - 2.7. Offline VS online 15
 - 2.8. Programmability 15
 - 2.9. Instant or not 16
 - 2.10. Fees or not 16
- 3. Arguments for: motivations / benefits 16**
 - 3.1. Monetary policy and operations 17**
 - 3.1.1. Fighting currency substitution (competing with foreign e-moneys)..... 17
 - 3.1.2. Improving monetary transmission mechanism 20
 - 3.1.3. Seigniorage income 21
 - 3.1.4. Dealing with effective lower bound on interest rates 22
 - 3.1.5. Making helicopter drops easier 23
 - 3.2. Financial stability 24**
 - 3.2.1. Stability of payment systems..... 24
 - 3.2.2. Continued existence of outside money 26
 - 3.2.3. Fighting currency substitution (competing with foreign e-moneys)..... 28
 - 3.2.4. Financial inclusion 29
 - 3.2.5. Smaller informal economy 30
 - 3.2.6. Lower counterparty risk 31
 - 3.2.7. More information for regulators 32
 - 3.3. Payment systems 33**
 - 3.3.1. Convenience..... 33
 - 3.3.2. Anonymity/privacy in digital payments 35
 - 3.3.3. Reducing cost of cash 36
 - 3.3.4. Reducing transaction costs 36
 - 3.3.5. Facilitate cross-border payments 37

3.3.6.	Supporting innovation	39
3.3.7.	Countering illicit activities	40
3.3.8.	Consumer protection	41
4.	Arguments against: potential risks / costs	42
4.1.	Monetary policy and operations	42
4.1.1.	Exacerbating effective lower bound problem	43
4.1.2.	Reducing monetary policy independence	43
4.1.3.	Increasing exchange rate volatility	44
4.2.	Financial stability	45
4.2.1.	Financial disintermediation	45
4.2.2.	Bank runs	48
4.2.3.	Larger state footprint in credit allocation	49
4.2.4.	Systemic risk of payment systems	51
4.2.5.	Financial exclusion	51
4.3.	Payment systems	53
4.3.1.	Technological risks	53
4.3.2.	Privacy concerns	54
4.3.3.	Supporting illicit activities	54
4.3.4.	Cost of operating CBDC infrastructure	55
4.3.5.	Driving private payment systems out	55
5.	Under-researched areas	56
5.1.	Interlinkages (between benefits, costs and design choices)	56
5.2.	Competition for money VS competition for credit	57
5.3.	CBDC and collateral policy	58
5.4.	Seigniorage income VS remuneration	59
5.5.	Account VS token	59
5.6.	Medium of exchange VS store of value	60
5.7.	CBDC and exchange rates	60
6.	Conclusion	60
	References	62

1. Introduction

Digital revolution is here and shaping “almost everything we do” ([Mühleisen, 2018](#)). It seemed only a matter of time before money and payments would go digital as well, as it already is doing ([Adrian and Marcini-Griffoli, 2019](#) or [OMFIF-IBM, 2019](#)). Even the recent COVID-19 crisis is pushing us into that direction¹ ([Auer et al, 2020a](#)). Despite this clarity, what is not so clear is whether those digital currencies should be privately issued (mostly in the form of so-called stablecoins) or publicly issued in the form of a central bank digital currency (CBDC)^{2, 3}. Because of this, international debate around a potential introduction of a CBDC is a topic that is probably going to only gain traction. The reason behind this, to be a little more precise, is two-fold: (1) increasingly many central banks are thinking about the introduction of a CBDC ([Central Banking, 2020](#)) as they “face tough competition” from private digital currencies, more specifically from stablecoins ([Adrian and Marcini-Griffoli, 2020](#)) and (2) CBDCs seem to have a huge and multi-dimensional (positive as well as negative) possible impact on (central) banking – something this paper will be digging into.

Indeed, what is most fascinating about CBDCs is that the topic that merely seems a technical one has so wide-ranging implications. Look, for example, at the job of central banks. Their essential role in maintaining macroeconomic (and, especially, price) stability using proper monetary policy has long been emphasized ([Friedman and Schwartz, 1963](#)) and still remains the mainstream ([Woodford, 2004](#)). Necessity of their involvement in maintaining financial stability has also, once again⁴, become pretty much mainstream as well since the Global Financial Crisis of 2007-2009 (GFC) and this has resulted in an expansion of the macroprudential policy toolkit ([Turner, 2010](#) or [Galati and Moessner, 2012](#)). On top of these, central banks have also been playing “a pivotal role in maintaining the safety and integrity of the payment system” according to the Bank for International Settlements ([BIS, 2020a](#)). And all of these three pillars of central banking can significantly and directly be affected by the introduction of a CBDC ([Mancini-Griffoli et al, 2018](#) or [CPMI-MC, 2018](#)). This complexity, for example, is what made Cecilia [Skingsley \(2016\)](#), the deputy governor of Sveriges Riksbank (which is one of the pioneers of CBDC pilots), to argue that “the Riksbank has never before launched such a complicated project in such an unknown area”.

While most economists now agree that the introduction of a CBDC will, indeed, have an impact on all three of monetary policy, financial stability and payment systems, they still

¹ Scientific evidence suggests cash is not as important a source of virus transmission as other frequently touched objects are. However, what matters for switching to digital payments is what public at large perceives. In addition, digital payments let us shop online (important under social distancing), while cash does not.

² Clearly, if you ask central banks themselves, trusted money is a public good (see [Group of Central Banks, 2020](#) – a report by a group of advanced central banks studying issues related to CBDCs).

³ Our definition of a digital money excludes money in the form of a checking account, as created by private banks. This is in spite of the fact that it of course is also fully digital in character and, with some imagination, can be seen as a good example of an effective stablecoin.

⁴ Central banks have traditionally played a role as lender of last resort, serving financial stability. This role is probably even older than monetary policy ([Bagehot, 1873](#)). Moreover, some measures that today are part of macroprudential policies have been available before.

strongly disagree whether the final net effect would be positive or negative. Even central bankers themselves are yet to find a common ground. Take, for instance, the Netherland's central bank that has "a favorable attitude to central bank digital currency"⁵ ([DNB, 2020](#)), while the close-by Danish central bank seems to still think that "the potential benefits of introducing CBDC for households and businesses in Denmark are not assessed to match the considerable challenges that the introduction would present" ([Danmarks Nationalbank, 2017](#)⁶). The reason is that while the literature on the topic evolves rapidly, the wide-ranging implications of CBDCs are still greatly under-researched⁷. The combination of these two makes it all the more important to occasionally take a break from specific details and have a broader look at (1) where we are (what do we know about all pros and cons and their interactions?) and (2) where we should be headed to (what specific aspects need more research?). This paper tries to answer those two questions based on arguably the most extensive survey of CBDC literature⁸ so far. Hence, for the time being, it could be a go-to starting point for economists wishing to get to the relevant nuts and bolts of the topic.

When it comes to the **first question** (*where we are*), the literature has identified dozens of potential benefits and costs/risks of a CBDC introduction. Starting with benefits, on a monetary policy front, the hope is that CBDCs may (i) help us deal with currency substitution or financial dollarization more effectively by increasing an appeal of domestic currencies, (ii) improve monetary transmission by increasing the reliance of market rates on a policy rate, (iii) increase seigniorage (with bigger central bank balance sheets), (iv) deal with effective lower bound using remuneration of a CBDC and (v) make helicopter drops easier with the public having access to a central bank money in a digital format. On a financial stability front, CBDCs may (i) make payment systems more stable by leveling the playing field / avoiding fragmentation, (ii) provide trust in today's monetary systems / at-par convertibility by providing access to an outside money in a digital form, (iii) fight currency substitution and lower financial stability risks, (iv) increase financial inclusion and financial deepening without too much risk taking, (v) lead to smaller informal economy that helps price credit risks better, (vi) lower counterparty risk possibly with smart contracts and (vii) potentially provide genuinely real-time information to regulators. Finally, on a payment systems front, a CBDC may (i) make payments more convenient in a digital world, (ii) create a widely accessible means of anonymity/privacy in digital payments, (iii) reduce cost of handling cash, (iv) reduce transaction costs/fees applied by merchants, (v) facilitate cross-border payments by

⁵ Although, one should mentioned that DNB was also negative back in 2018, until it changed its mind explicitly, probably because of the introduction of Libra in 2019 (later called Diem).

⁶ Note though that Denmark has a fallback option – switching to euro as of yet, if deemed necessary.

⁷ Even though many central banks do not currently plan to issue a CBDC, many acknowledge they should be ready to do so in the future. And, as argued by [Panetta \(2020\)](#), this means the preparations should already be happening due to time it takes to understand the complexities.

⁸ The aim, though, is not to cover as much CBDC papers as possible, but to cover as much CBDC benefits/costs/risks as possible, that have so far been identified in the literature. Hence, some very useful papers may not be directly referred to here, because, hopefully, what benefits/costs/risks those papers identify have already been covered here by referring to another similar paper.

avoiding (costly) legacy systems, (vi) support innovation in a level playing field, (vii) counter illicit activities (even with third-party anonymity) and (viii) strengthen consumer protection.

Obviously, depending on design choices (covered below), there are significant downsides as well. On a monetary policy front, a CBDC may (i) exacerbate the effective lower bound on interest rates (if CBDC remuneration is not time varying), (ii) reduce monetary independence hand-in-hand with the possibility of helicopter drops and (iii) increase exchange rate volatility. On a financial stability front, a CBDC may (i) generate financial disintermediation by increasing interest rates and cost of funds, (ii) make (digital) bank runs more probable or faster, (iii) force central banks to get involved in credit allocation, (iv) increase systemic risks of payment systems with a single point of failure and (v) lead to more financial exclusion (of mostly elderly). On a payment systems front, a CBDC may (i) increase technological risks with new technologies that still have to stand the test of time, (ii) generate privacy concerns if authorities would be monitoring transactions, (iii) support illicit activities if it's "maximally" anonymous, (iv) generate big costs of operating an infrastructure and (v) drive private payment systems out of the market, unless an intermediated version of a CBDC is implemented.

In terms of the **second question** (*where we should be headed to*), the most important missing piece in the literature, in our view, is to systematize the three-dimensional linkages between benefits, costs/risks and design choices. Our paper tries to lay some ground for developing such a systematic framework by providing (i) needed design choices along each item in the list of benefits / risks to-be-mitigated and (ii) what other benefits / risk-mitigation aims these design choices may be in conflict with. In addition, there has been less attention to how money creation really works in contemporary banking systems, yet understanding this in a CBDC context will define whether we should be expecting financial disintermediation or not⁹. Also, CBDCs may require us to think more about central banks' collateral policy, interest rate elasticities, technological clarity, role of money in general and potential effects on exchange rates. These are all difficult questions, as also discussed below, and require more fundamental research.

The paper is organized in the following way: Section 2 introduces a CBDC by discussing potential design choices/features/principles. Section 3 discusses potential benefits of a CBDC in more detail, while the next section does so for potential risks/costs of a CBDC. Section 5 digs deeper into what areas of CBDC literature need more scrutiny, while the last section concludes.

2. Design principles

Before turning to sketching all the arguments known so far for and against the introduction of a CBDC, we should first define it and discuss the characteristics (design principles) that can be given to it. In general, defining what money is can be a tricky task. For instance, according to [Kocherlakota \(1998\)](#) money serves the role of a memory (knowledge of all

⁹ The literature has argued in favor of all three: CBDCs generating financial disintermediation, having no effect on financial intermediation and increasing financial intermediation.

agents' histories and their imaginary balance sheets) and, hence, "money is memory". However, given that we already have money (cash and deposits) as a benchmark, in order not to divert our attention to a somewhat different and deep topic, we will be "defining" a CBDC in terms of how it compares to existing forms of money in terms of all key characteristics. This is helpful, because a simple definition of a CBDC can be very misleading. For example, some define it as a "digital cash" (e.g. [Dyson and Hodgson, 2016](#)). However, if CBDCs were only a digital version of cash, it would not have such wide-ranging implications. Indeed, CBDCs can differ from cash not only in terms of the form (digital VS physical), but also in terms of scope (who it is available to), remuneration or even anonymity and (de)centralization. Those are the design principles that policy makers need to take a decision upon and only after that will it be possible to decide whether a CBDC is really just a digital cash or something more. Hence, after some discussion, [BIS \(2021a\)](#) concludes that directly comparing a CBDC to paper currency in a simple manner is "an inaccurate analogy to how a CBDC would operate. In this sense, CBDCs have attributes that are very different to those of cash, even though both are direct claims on the central bank". Also, worth noting that "[t]hese design features are not discrete", so that some of them (e.g. anonymity) can be incorporated only partially ([Group of Central Banks, 2020](#)).

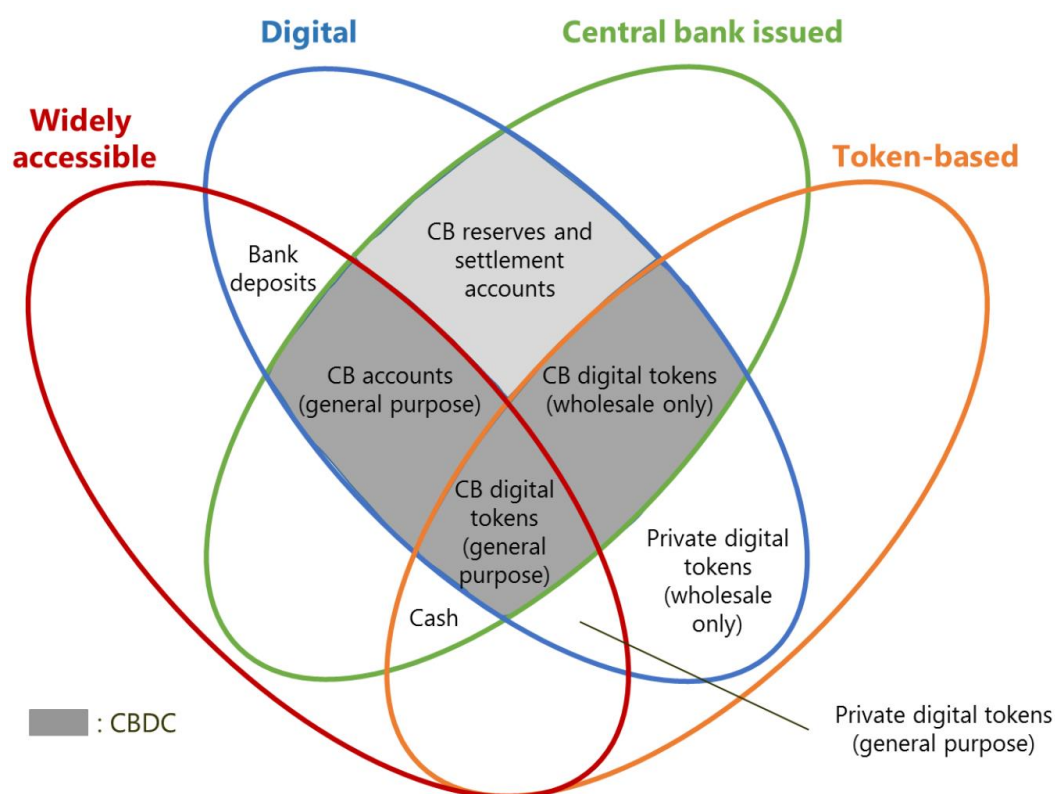
The only things that are sure about CBDCs are that it would be central bank-issued (CB), in a digital form (D) and used for payments¹⁰ (C). One version of a definition by [OMFIF-IBM \(2019\)](#) comes close¹¹: "CBDCs can be defined as a digitalized instrument issued by the central bank for payments and settlements"¹². The rest is a matter of design principles. [Bech and Garratt \(2017\)](#) tried to describe what CBDC is relative to other currencies using a Venn-diagram. However, their diagram only considers four properties, whereas full description of any particular CBDC would require showing much more properties (design choices). [CPMI-MC \(2018\)](#) uses a similar approach of a Venn-diagram of four properties (see Figure 1). Yet, while this Venn-diagram makes us think that there are three distinct types of CBDCs that we can introduce, the reality is much more complex. Each of these three types can be remunerated or not, centralized or not, have fees or quantitative limits or not and so on. Therefore, the dimension is much wider than the diagram shows, even though it's still useful for starting to think about CBDCs. Indeed, [CPMI-MC \(2018\)](#) itself goes on and overviews those other design choices discussed below.

¹⁰ Naturally, it will also be a denomination of a national currency. Having a legal tender status is part of the question as well but what's confusing is what this may mean in a digital form, as the legal tender status has varying meanings (e.g. between the eurozone member states).

¹¹ See also the definition by [Engert and Fung \(2018\)](#): "central bank digital currency (CBDC), at the most basic level, is simply monetary value stored electronically that represents a liability of the central bank, is available to the general public, and can be used to make payments."

¹² [DNB \(2020\)](#) also discusses how broad the definition is, but then goes on to equate wholesale CBDC and central bank reserves, because they are both digital (electronic) and central bank issued. This is true in a sense that reserves are a special case (one possible version) of a wholesale CBDC. However, wholesale CBDCs and existing reserves can still be different in terms of other design principles listed below (e.g. anonymity).

Figure 1 – CBDC in a Venn-diagram



Source: [CPMI-MC \(2018\)](#)

As mentioned, these wide-ranging design principles will define what CBDCs will be in the end and, hence, how they will disrupt existing payment systems or affect financial stability and monetary policy. Those principles are usually discussed after listing the pros and cons of CBDCs. However, given those pros and cons directly result from specific design choices, it makes sense to first discuss those design principles for that one has a better idea what is the precondition for a specific pro or con in terms of design choices. Legal questions also need to be addressed. For instance, as emphasized by [Fabio Panetta](#) in the review of [Gnan and Masciandaro \(2018\)](#), “if the CBDC is legal tender, does this mean that everybody will *need to have* the technical means to accept it?” (*emphasis own*). Hence, designing CBDCs in a specific way will also need to be in line with the legal framework (see also [DNB, 2020](#)), but that is beyond the scope of this paper. The assumption is that whatever design choices are made, they will be supported by the legal system (even if with legislation changes).

2.1. Degree of anonymity

Anonymity is an important feature of cash. However, it complicates the problem of capturing money-laundering cases. That is why, acknowledging its inability to work smoothly in CBDC applications, full anonymity is what [Carstens \(2021\)](#) calls a chimera. [CPMI-MC \(2018\)](#) notes that a totally anonymous CBDC would be unlikely to be considered because its inability to meet Anti-Money Laundering / Combating the Financing of Terrorism (AML/CFT) requirements. However, there are approaches that make it possible to ensure third-party anonymity while making sure that movement of money can still be accessed if necessary. The question is: do consumers value anonymity over other features of money and the answer

strongly varies between countries. In some countries, while people using cash may be used to full anonymity, both experiments and practice show that they will quickly revise their demand for anonymity if other features of money provide at least some small incentive ([OMFIF-IBM, 2019](#)). However, some (downplaying the possibility of criminal usage of anonymous cash) argue that tracing of individual transactions still sounds discomforting, even when nowadays most people do pay more often using their bank accounts (which are traceable) than by cash¹³.

As [DNB \(2020\)](#) puts it, CBDCs may not be able to achieve as much anonymity as cash (because of their digital form), but they may be able to provide more anonymity than private forms of money, because “the central bank does not have a commercial incentive to profit from the use of data (for example through targeted advertising)”. Yet someone may still “sometimes have to examine transactions... given their public role, such as monitoring money-laundering, terrorist financing and other illegal activities”. Yet [Ali and Narula \(2019\)](#) argue that compliance with the AML/CFT-type regulation can be provided even in cases when privacy is ensured. Or, in their own words, “one can engage a third-party auditor who can get provably correct information about reserves, transaction size, market concentration, and more without revealing the contents of individual transactions”. This is done using a so-called zero-knowledge proof protocol. However, given its importance, the way this can be AML/CFT compliant would need to be explicitly and clearly communicated by the authorities.

In addition to AML/CFT issues, [Lannquist \(2019\)](#) emphasizes another downside of full anonymity: impossibility of reversing fraudulent or mistaken transactions (or lost funds). In other words, another reason why full anonymity (as opposed to pseudonymity) is impossible even in a decentralized CBDC¹⁴ is that a regular check with the system is necessary to prevent “digital counterfeiting” or “double spending”. Put differently, an issue with complete anonymity (coupled with instant settlement, i.e. without credit risk) is the legal risk related to irrevocability ([CPMI, 2015](#)). There is the same issue with cash (if somebody steals it, how easily can you prove it belonged to you in the first place?), but in case of digital currencies this problem can be on a scale orders of magnitudes larger.

Anyways, [ECB \(2021\)](#) offers a couple of techniques for enhancing privacy options, including one-time pseudonyms for each transaction and transactions mixing, where multiple users mix their transactions to make them less traceable. Hence, as technology seems to provide us ways to achieve anonymity, (almost) full or partial, now it is a design choice that policy-makers will need to decide on.

2.2. (De)centralization

Distribute ledger technology (DLT) is the primary technology discussed as an alternative to a centralized record keeping done by a central bank. It has its advantages as well as costs.

¹³ This may suggest that most people do not really care as much for full anonymity, as long as there is an *option* available for those transactions where anonymity is seen as very important.

¹⁴ A balance on a token, which can be used for peer-to-peer transactions.

„Permissioned DLT¹⁵ designs may have economic potential in financial markets and payments due to enhanced robustness and the potentially lower cost of achieving good governance, as compared with systems with a central intermediary. However, such resilience does not come for free, as an effective decentralised design that ensures the right incentives of the different validators is costly to maintain. On balance, a trusted centralised design may often be superior, as it depends less on aligning the incentives of multiple private parties“ ([BIS, 2021a](#)).

In terms of benefits of a DLT, the survey of [OMFIF-IBM \(2019\)](#) shows that more than 20% (of 23 central banks included in the survey) prefer decentralized systems meant to improve resilience. As argued there, decentralized systems with “[d]istributed ledgers that enable off-network transactions would add another contingency to legacy systems against lost connectivity. Such advances may shrink the divide between rural and urban populations in terms of energy, connectivity and financial inclusion”. In addition, DLT may easily allow a CBDC to become a programmable money (e.g. transactions and conditions for executing those transactions being automatically linked). [Wolfram \(2020\)](#) also emphasizes the resiliency argument of distributed systems – no single point of failure.

However, several problems with DLTs are mentioned as well. First, they may have a hard time when it comes to scalability – processing large numbers of transaction in a short period of time without a centralized system seems difficult so far. [OMFIF-IBM \(2019\)](#) notes that fully centralized systems are more efficient when it comes to scalability, because it can easily “check the validity of tokens’ serial numbers, and then reassign numbers once tokens change wallets to avoid double-spending risk. Visa’s 50-year-old VisaNet can process on an average day 1,700 transactions per second and up to 20,000 during peak periods. Peak online transactions in China have reached 92,771 per second and China’s DCEP (digital currency electronic payment) is expected to be able to process 300,000 transactions per second ([Fanusie and Jin, 2021](#)). Bitcoin processes fewer than five per second and settlements can take up to an hour”¹⁶. The difference between centralized and decentralized systems could be huge in this sense. Permissionless systems seem still waiting for the technology to robustly advance in a way that helps their scalability in a secure way. Despite this, an online poll by [OMFIF \(2020\)](#) shows that it is not slow transaction speed that most respondents believed to be the biggest barrier to blockchain adoption, it is risks around transition.

While there is an ongoing work to improve upon this problem of scalability, this may not be sufficient just yet. Namely, “[r]esearch on scalability has shown that performance problems associated with public DLT networks (that require mining or other consensus protocols) can be overcome with permissioned DLT networks. Nonetheless, estimating current and future volumes and throughput requirements for a CBDC is complicated and exacerbated by other industry developments (eg payment requests generated by smart devices and the potential for high volume micro transactions)” ([Group of Central Banks, 2020](#)). Also, “decentralised ledger could bring some operational resilience benefits, although so could a centralised ledger with multiple data centres”. Second, consensus protocols provide only probabilistic finality – you cannot be sure if your transaction is settled with full certainty. In addition, a

¹⁵ Permissioned DLT is a technology where designated validators verify transactions and update the ledger.

¹⁶ It’s an interesting question whether or not the lightning network can make a difference here.

CBDC that is totally decentralized and anonymous is also problematic as AML/CFT issues would multiply, even if open or “enterprise-grade” blockchain could contain some remedies. As argued by [WEF \(2020\)](#), even within the decentralized system, “[t]ransaction approval could follow a pre-specified consensus process determined by the central bank, which could include privileges for the central bank such as transaction ‘veto’ powers or visibility”. Yet, while there are several enterprise blockchain solutions, choosing one DLT solution over another when all of them are still new and immature, seems like a big risk and “increase vendor lock-in” ([WEF, 2020](#)).

Another issue with decentralized systems like Bitcoin (that involve proof-of-work consensus algorithm) is its excessive cost in terms of electricity ([BIS, 2018](#)), however such concerns may not be valid anymore for other approaches like proof-of-stake consensus algorithms. Still, [Ali and Narula \(2019\)](#) discuss why it is not necessary to introduce a decentralized CBDC using the Distributed Ledger Technology. They also note the scalability advantage of having a traditional centralized approach (centralized CBDCs being able to process more transactions). A usual example in this discussion is Bitcoin¹⁷ (fully decentralized) versus Visa (centralized), as noted above. Finally, while fully decentralized systems help us in avoiding the use of trusted intermediaries (which may be important in countries where institutions like a central bank may enjoy some trust but not sufficient trust¹⁸), this, however, does not mean there is no trust needed even in decentralized systems. Here users should trust the decentralized consensus and it is unclear who will act if the trust in this consensus evaporates ([DNB, 2020](#)). In addition, whether transactions will be processed in a centralized or decentralized way, it seems that it will be the central bank that will manage and determine the size or the amount of CBDCs in circulation¹⁹. Then the only other thing left for us to trust, is the finality of payments and this is, actually, where decentralized cryptocurrencies fare badly relative to centralized currencies ([Carstens, 2019](#)). In other words, the main aim of Bitcoin was to avoid the use of central banks that can inflate away the public sectors liabilities²⁰. Then, without this (inflation hedge) the only use case for full decentralization (of a CBDC) seems to be avoiding a central counterparty nulling/controlling our accounts. However, again, this is where fully decentralized currencies (where finality is only probabilistic) fare relatively badly.

Still, if distributed systems are to be used for several purposes, there could also be a middle solution. This involves having a two-tiered or sometimes called hybrid system where “in the first tier of a two-tiered CBDC, the central bank would create and issue the CBDC to

¹⁷ As we understand, there are other crypto assets that are faster than Bitcoin. Some blockchains have a more acceptable performance. Moreover, the BTC lightning network is under progress, although such a second layer approach may violate the principles of the blockchain.

¹⁸ Sometimes the differentiation is done as developed versus developing economies. But in this particular context, it’s better to split developing economies into still another two groups: (1) countries, usually poorer and less developed than advanced ones, with underdeveloped financial systems (low degree of financial inclusion, mostly cash based, etc.), but *enough* confidence in the government/central bank and (2) countries where governments/central banks are not trusted, which usually manifests itself in a hyperinflation (e.g. Zimbabwe or Venezuela).

¹⁹ A CBDC that is not issued by a central bank is by definition not a CBDC.

²⁰ Even though some may characterize it as a Ponzi scheme (e.g. [Boonstra, 2021](#)).

commercial banks without the involvement of DLT. In the second tier, commercial banks or other intermediaries could redistribute the CBDC to the end citizens over the DLT network if desirable” (see [WEF, 2020](#)).

2.3. Retail VS wholesale

Another way of classifying payment systems is differentiating between retail and wholesale systems. While retail systems serve the general public (and, hence, have to handle a very large number of usually low-value transactions), wholesale ones may be restricted to certain parties (that may make them faster). For instance, the comparison can be card payments (e.g. debit or credit)²¹ VS interbank payments (e.g. through RTGS²²). And when it comes to CBDCs, they can be both. If a CBDC will be a wholesale system, this will have very different implications, relative to it being a retail system²³. Given that banks already deal with each other using central bank reserves, which are already in digital form and remunerated, one may think that there is not much difference between a wholesale CBDC and reserves. But a wholesale CBDC can still be different if it’s anonymous, decentralized or maybe able to work offline. However, it is difficult to imagine a scenario where central banks would indeed do these, at least the full anonymity part. Hence, in the remainder of the paper, a CBDC would most frequently mean a retail one unless otherwise noted in the context.

According to [BIS \(2020a\)](#) another benefit of a wholesale CBDC could be introduction of a programmable money, in addition to being more resilient to cyber-attacks (improving irrevocability of record-keeping on a blockchain). However, it is a different thing to ask whether these are features very important for financial intermediaries themselves or not. The academic literature has not concentrated on this question much. The reason can be that maybe, implicitly, economists think it will not be a game-changer. As for the private sector perspective, [OMFIF-IBM \(2018\)](#) argues that wholesale CBDCs can be faster, more efficient, with lower counterparty risk and resilient. Despite this, the report also concludes that wider policy implications would be very few – strengthening the presumption that wholesale CBDC will not be a game-changer (maybe except for cross-border transactions). [CPMI-MC \(2018\)](#) argues that, while central bank reserves are already digital, a wholesale CBDC “combined with the use of distributed ledger technology, may enhance settlement efficiency for transactions involving securities and derivatives”. However, whether this would be superior to existing infrastructures is still to be seen.

On the other hand, if a CBDC will be a retail system, it can indeed become a game-changer ([OMFIF-IBM, 2019](#)). As will be discussed below, most of potential big benefits as well as big costs/risks of a CBDC come from it being a retail system. Hence, cost-benefit analysis of a retail approach would crucially depend on other design features.

²¹ Sometimes these can take a couple of days to settle.

²² Real time gross settlement. Clearly, as the name suggests, these are settled in real time.

²³ Indeed, most of the public debate is about retail CBDCs. This is the more drastic change. Wholesale systems may be a parallel development.

2.4. Remuneration

[OMFIF-IBM \(2019\)](#) reports that, according to its survey, central banks do not consider interest-bearing CBDCs worth pursuing, as it “would alter the composition of the overnight rates complex”. However, in that same report, it is argued that CBDC’s interest rate and interbank interest rate differences may create undue arbitrage opportunities. Namely, on the one hand, if an interest rate on a CBDC is higher than an interest rate on reserves, banks would borrow reserves from other banks and a central bank to reinvest them into CBDCs that yield higher return, with this arbitrage exploitation driving interbank rates up to the rate on CBDC. On the other hand, if interest rate on CBDC is lower than that on reserves, then arbitrage opportunity would make interbank rates drop down to a rate on a CBDC ([OMFIF-IBM, 2019](#)).

But the problem with that reasoning is that, if it’s right, then the entire discussion about whether CBDCs should be interest bearing or not is a complete waste of time. If that kind of arbitrage does drive short-term market rates then it means that, as long as central banks want to have a control on short-term interest rates in the financial system, they *must* remunerate the CBDC at exactly the policy rate of central banks (or inside the interest rate corridor). Otherwise, CBDCs without remuneration (i.e. zero percent interest rate) would always drag interbank rates down to zero. However, is this the case? For CBDCs remunerated above the policy rate, probably yes ([CPMI-MC, 2018](#)), but for CBDCs remunerated below the policy rate, probably not²⁴. Take cash for example. Cash has a zero percent interest rate, while reserves (usually) bear a positive interest rate²⁵. Does this mean that arbitrage opportunities drive interbank (market) rates down to zero? Absolutely not. As long as central banks have standing facilities, then it is not the market that determines short-term risk-free rates (i.e. arbitrage), it is the central bank that sets them (as a monopoly supplier of a central bank money). For a discussion on monetary policy operations and interest rate management see [Maehle \(2020\)](#). Hence, remuneration of a CBDC is still a design principle that we have a choice about.

Another issue with remuneration is it challenging the anonymity feature. For interest to be paid, the legal holder would probably need to be known. In addition, if interest income is taxed, central banks would have to provide the confidential details to the tax authorities. Smart contracts could be a possible future solution to these anonymity issues for remunerated CBDCs ([OMFIF-IBM, 2019](#)).

2.5. Direct VS indirect/hybrid

Several surveys show that central banks are almost unanimous that a CBDC framework should not be a direct one, with all the services (like customer onboarding) provided by the central banks themselves (see e.g. [OMFIF-IBM, 2019](#)). While there could be rare cases in

²⁴ The reason of asymmetry is the presence of collateral constraint (for borrowing from central banks), which itself, by definition, is asymmetric. If banks borrow from a central bank en masse, to exploit arbitrage, they will eventually hit the collateral constraint, after which uncollateralized interbank lending rates would indeed start increasing towards the higher CBDC rate. The opposite is not true, as banks can always deposit excess liquidity at the lower bound of the interest rate corridor (that usually is pretty close to the policy rate).

²⁵ Even if, over the business cycle, some central bank policy rates may happen to be at zero.

favor of a direct approach²⁶, in more general terms, there should be a role for the private sector to e.g. onboard customers and manage wallets – resulting is a form of a public-private partnership. A direct approach is especially costly for larger economies. [DNB \(2020\)](#) also seems to favor a non-direct/hybrid approach as articulated by the [Bank of England \(2020\)](#). In this hybrid approach, central banks manage the core ledger, but let private Payment Interface Providers to connect to it through Application Programming Interface (API). In the words of [Adrian and Marcini-Griffoli \(2019\)](#) that kind of a hybrid approach “preserves the comparative advantage of the private sector to innovate and interact with customers, and of the central bank to provide trust and efficiency”²⁷. This approach also means that central banks would retain their central position in the financial system. In a direct system, central banks would develop into direct competitors to private/commercial banks, which would necessitate a drastic reform of the supervision structure.

As [BIS \(2021a\)](#) puts it, “there are good arguments against a one-tier system fully operated by the central bank, ie a direct CBDC... [which] would imply a large shift of operational tasks (and costs) associated with user-facing activities... Most fundamentally, a payment system in which the central bank has a large footprint would imply that it could quickly find itself assuming a financial intermediation function that private sector intermediaries are better suited to perform”. Indeed, private banks have much better knowledge of individual (borrower) level credit risk and are thus better suited to allocate resources accordingly – a key function of private markets ([Hayek, 1945](#)).

2.6. Quantitative limits

Setting a quantitative limit on holdings of a CBDC may be desirable if one wants to limit the competitive pressure to private monies (like bank deposits) and prevent potential bank runs. [Bindseil \(2020\)](#) actually advocates this approach coupled with the price-based incentives. Or more specifically, he argues that a two-tiered system, where small amount balances will be available with better terms, while larger ones with worse terms, is an optimal way to go (to deal with bank disintermediation risks). Hence, this is similar to differentiating small and large amounts (akin to quantitative limits) and making one more attractive, while the other more costly (akin to fees or remuneration). However, in times of crisis, this kind of “soft” limits will not be sufficient to stem banks runs if there is a collapse in confidence. The latter case may require “hard” limits. Operating hard limits are technically easy and possible. Earlier a potential problem was identified “that households or firms that have reached their cap could not accept incoming payments, resulting in a broken payment process” ([BIS, 2021a](#)). However, a solution²⁸ to this is that “funds in excess of a cap could be transferred automatically to a linked commercial bank deposit account – the so-called overflow

²⁶ For example, very small countries may prefer a direct approach with more control, since customer-facing tasks may not be very challenging due to small number of people. And thinly populated counties may lack the availability of a private banking network, which of course is essential for an indirect approach.

²⁷ Though, if the private sector here means commercial banks or not is a different question. We don’t know whether banks would be able to use their current systems for onboarding CBDC clients. If yes, it would help them in the competition with other parties. If onboarding for a CBDC transaction necessitate a new parallel system their costs may double. Banks may even consider not to offer CBDC services in that case.

²⁸ This requires consumers to have bank accounts though.

approach”. Indeed, [ECB \(2021\)](#) has found a “way of automatically transferring the excess amount (e.g. if an incoming transaction sends a digital euro balance above a certain limit) to an account/wallet in private money that is paired with the digital euro account/wallet”.

The problem of quantitative limits, however, is that it potentially creates an implicit wedge between cash and CBDC values or prices²⁹ (i.e. creates a value premia, see [WEF, 2020](#)). There is the same problem in case of fees, but here this problem is much worse. In case of fees we know how big this wedge is (i.e. it’s price-based), but with quantitative limits we have no idea what the shadow price of this limit is. Hence, with hard quantitative limits the price of CBDC in terms of cash can fluctuate wildly sometimes, driven by fluctuations in CBDC demand³⁰. But according to [Agarwal and Kimball \(2015\)](#) this could actually be useful to break through the zero (or effective) lower bound, since there would be a floating exchange rate between a CBDC and cash or deposits (as opposed to one-to-one convertibility). However, with such limits, the convenience and (implicitly) fungibility of CBDCs is still at risk and this is not what central banks would want.

2.7. Offline VS online

Many central banks prefer CBDCs to be available offline and be able to function wherever cash is used currently. The advantage of an offline CBDC is that it is resilient to power and connectivity outages or cyber-attacks. However, in some cases, offline functionality may risk the possible double spending problem. The solution to this may be somewhat similar to existing rules governing card payments ([OMFIF-IBM, 2019](#)). As argued by [DNB \(2020\)](#), offline functionality (or to be more precise, value-based CBDC in their context) is risky in terms of counterfeiting: “Should the cryptography of, for example, smart cards be cracked, large amounts of CBDC could be created outside of the central bank”, possibly without the central bank knowing. Hence, [DNB \(2020\)](#) would prefer a more-traditional account-based CBDC. Although, the solution will probably incorporate a limited amount of offline functionality, with a regular check with an online system. In other words, as emphasized by [ECB \(2021\)](#), while it is technically feasible to allow offline payments, “transactions cannot be offline indefinitely, i.e. offline devices will at some point need to resynchronise with the online ledger”.

2.8. Programmability

According to [DNB \(2020\)](#) the advantage of a simple payments-only CBDC (i.e. non-programmable) is that it is easier to operate with the current infrastructure. Programmable money, on the other hand, seems future-proof – being able to adapt to potential future needs

²⁹ This is similar to central banks limiting an amount of cash withdrawals in uncertain times / during bank panics (e.g. Greece during the euro crisis).

³⁰ For example, if one person hits the limit of CBDC holdings and wants to hold even more (i.e. wants to convert some part of its cash/deposits into additional CBDCs), it will not be able to. Then, this person would be willing to pay (maybe slightly but still) more than one euro cash for one euro worth of CBDC. When the limit is hard and enforced well, we will never know how badly this person wants to convert cash into CBDC. However, if there were loopholes - we might. For instance, if this person is offered a “custodial service” by another person (abstracting from credit risk) who has not yet hit the limit of CBDC holdings, then we could see how much premium this person offers the other for holding extra CBDCs on her/his behalf (i.e. how much more on top of one euro is she/he willing to pay for holding one euro extra CBDC).

and, hence, driving demand for CBDCs.³¹ Cash is at the one extreme with payments-only infrastructure, while the previously proposed version of Libra/Diem, for instance, seemed to offer a wide range of possible features³².

2.9. Instant or not

Real time settlement within a CBDC infrastructure is indeed one of the benefits of such a digital currency. For it to be offering something new though, compared to already existent payment systems (e.g. RTGS), it has to offer additional features, like offline functionality. However, if a CBDC is also offline, for instance, this may expose some parties to a credit risk ([OMFIF-IBM, 2019](#)), in a sense of smart cards being cracked or counterfeiting (see above). The final settlement only will take place when the card synchronizes with the ledger. In a literal sense though, payment could indeed transfer tokens from one card to another, being able to settle directly and instantly.

2.10. Fees or not

CBDCs may entail some fees, driving a (potentially additional) wedge between them and cash. This may be useful for partly dealing with effective lower bound (setting negative interest rates to an extent) or covering costs of operating a CBDC infrastructure. However, the former benefit may be limited in size for some countries³³, as too negative rates may make CBDC holders to rush to e.g. foreign currencies ([OMFIF-IBM, 2019](#)) or cash. In addition, remunerating a CBDC (discussed above) at a below-market interest rate is already a form of a “fee”.

3. Arguments for: motivations / benefits

How beneficial, as well as costly, introduction of a CBDC would be depends on how big demand for it would turn out to be. As argued by [Khiaonarong and Humphrey \(2019\)](#) demand for a CBDC may be larger in economies where the dependence on cash is larger. However, context is important – a CBDC is, indeed, sometimes promoted as an alternative to cash in cash-based systems, but it can also be an alternative when cash disappears (i.e. countries close to becoming cashless). [Segendorf \(2018\)](#) finds something similar about the potential demand for e-krona in Sweden, where the use of cash is quite low and declining (even if cash in circulation in absolute terms may still be increasing). While the importance of CBDCs

³¹ However, programmable money may be at odds with privacy. For example, the Dutch Parliament is discussing an absolute prohibition of programmable money, as it may open opportunities to interfere with people’s private lives.

³² One may argue that programmable money can also be developed in the current system, without introducing a CBDC.

³³ E.g. if the ECB, Fed or Bank of England would have negative CBDC rates, one may not expect a massive run into, for example, Swedish Krona. Here, it is more likely that cash demand would increase instead. Yet, run into foreign currencies can indeed be an issue for emerging economies that are already familiar with the concept of currency substitution and liability dollarization.

stemming from this may be true (i.e. CBDCs merely being “a complement to physical cash”), we know that CBDCs can be much more than that – they can also compete with deposits, something covered in more depth in the next section.

Motivations for issuing CBDCs can be not only diverse, but also different jurisdictions may look at it differently ([Boar et al, 2020](#)). One way or another, policy-makers on average seem to have changed their stance about a CBDC from negative to positive ([Auer et al, 2020b](#)) probably because of the benefits listed below becoming more visible. We provide the discussion of these benefits compiled from many different sources/papers. More importantly though, at the end of each subsection describing a given benefit, specific design choices are provided needed for that particular benefit. Then we look at what this design choice will imply – will it exclude some other benefit or introduce risks? We do a similar stocktaking for potential costs/risks as well. The aim is to lay some ground for systematizing three-dimensional interlinkages between CBDC benefits, costs and design choices.

3.1. Monetary policy and operations

As we discussed in the introduction, while CBDCs may just look like a topic of payments technology, it actually has wide-ranging implications, including on a monetary policy front. This is what we discuss in this section, emphasizing the possibility of making monetary policy more efficient and effective in achieving its objectives. This includes countering a dollarization threat, improving monetary transmission as well as (potentially) dealing with the effective lower bound on nominal interest rates – an issue faced by many advanced country central banks.

3.1.1. Fighting currency substitution (competing with foreign e-moneys)

First, a central bank issued digital currency may be useful in avoiding deterioration of monetary policy effectiveness possibly brought by so-called dollarization³⁴. One risk is that foreign public monies (like the US dollar) could replace domestic public currencies, but the other related risk is domestic public monies being replaced by private digital currencies like stablecoins ([OMFIF-IBM, 2019](#)). These possibilities may have similar implications in terms of monetary policy (both eliminate monetary autonomy). However, they could have very different implications for financial stability (one could be more destabilizing for the domestic economy than the other). Since private digital currencies are believed to be more volatile or risky, trying to mitigate the latter risk could be an important use case of a CBDC ([G7, 2019](#)). It's true that private crypto-currencies taking over the world's monetary systems is a long shot and many central banks do not consider this use case to be the primary one ([OMFIF-IBM, 2019](#)), at least for economies, where persistent inflation hasn't been much of a problem. However, stablecoins (like Diem was planned to be) may be a development that central banks

³⁴ This concept here is meant to capture usage of other currencies both as a medium of exchange (sometimes referred to as currency substitution) and as a means of saving (sometimes referred to as asset substitution or financial dollarization).

do consider as a potential motivator for issuing CBDCs, inter alia for maintaining monetary autonomy.

The possibility of a domestic currency being substituted by a foreign central bank money (like the USD) also seems a more down-to-earth problem, at least in emerging as well as small open economies, which are already used to US dollar denominated debt ([Cãtao and Terrones, 2016](#) or [Bruno and Shin, 2019](#)) and dollar invoicing in international trade ([Gopinath et al, 2010](#) or [Boz et al, 2017](#)). As opposed to an issue of private currencies taking over, many central banks do think that CBDCs can be useful for fostering trust, in general, in their own (public) currencies (that's what 69% of survey respondents think according to [OMFIF-IBM, 2019](#)), especially when (and if) cash becomes a thing of the past. The importance of this is manifested during economic turbulence, when there is a rush into central bank monies (which is cash nowadays). The problem of currency substitution will probably be more acute if foreign central banks issue a CBDC that is interoperable internationally (and, hence, easy to use to substitute domestic currency), such as DCEP (at least regionally). This happening could be likely, given the geopolitics, e.g. cold war (for global dominance in international payments) between the US and China ([Birch, 2020](#)). [ECB \(2020\)](#) also points to a similar problem: if foreign currency or multi-currency stablecoins were to become the dominant means of payment, monetary policy would have a harder time affecting domestic developments, as in dollarized countries. Similar concerns and, therefore, usefulness of CBDCs against them have been underlined by [Adrian and Marcini-Griffoli \(2019a\)](#) or [Brunnermeier et al \(2020\)](#) and [DNB, \(2020\)](#). See also [Auer et al \(2021a\)](#).

Yet, there is also a view that dollarization is a somewhat different issue. As per [BIS \(2021a\)](#), "dollarisation is typically higher in countries with historically high inflation... A foreign currency is unlikely to gain a domestic foothold just because it is digital". Indeed, according to a 2021 survey by the Bank for International Settlements (BIS), while stablecoins may be seen as a threat to monetary sovereignty³⁵ and "[d]espite the broad attention paid to stablecoins, concerns about their emergence as an alternative payment method are not a widespread motivation for work on CBDC – only a handful of central banks included them in their rationales for possible CBDC issuance" ([Boar and Wehrli, 2021a](#)).

May require specific design choices:

Even though it is not something domestic central banks can do much about, if foreign central banks decide to restrict their CBDCs to their economies (and possibly tourists as well coming into their countries), then domestic central banks will face less of a pressure / currency substitution. Indeed, this is what [Auer et al \(2021a\)](#) find in their survey of central banks. Namely, "[f]ewer central banks are open to allowing usage of their CBDC by non-residents abroad, given the risks this may entail for the issuing and recipient economies". Yet, the potential currency substitution threat from stablecoins remains. For the latter "central banks may reconsider their approach to exchange restrictions" ([Auer et al, 2021a](#)). Yet, while "[o]ne avenue to counter currency substitution is additional monitoring and controls... these must be carefully weighed against other design objectives such as convenience and flexibility".

³⁵ (Close to) full dollarization is the ultimate surrender of monetary autonomy.

More generally, any design feature that is meant to make a CBDC convenient will help on the currency substitution front – incentivizing residents to remain within the domestic currency system. These design features, as also discussed below, include privacy, programmability, finality, resilience against power outages (possibly through decentralized systems) and possibilities of offline functionality as well as remunerated at a rate close to market rates.

Needed design choices may exclude other benefits or involve risks:

A fully anonymous CBDC would preclude the possibility of countering illicit activities. Hence, there should be a balance between privacy and some (at least minimum) amount of AML/CFT compliance. Simply observing the usage of (private) deposit money that is not fully anonymous, it seems that at least some level of (e.g. third-party) privacy is sufficient for most customers. In terms of quantifying the role of anonymity for consumers, [Borgonovo et al \(2021\)](#), based on laboratory experiments, estimate that customers assign 1.44% higher value to an anonymous medium of exchange relative to a non-anonymous one. This shows that on average customers do value anonymity, but not too much as it seems³⁶. Indeed, the authors conclude that for customers liquidity and expected return is more important than anonymity. Finality is another customer-appealing feature, but it may also exclude the benefit of improved customer protection (if funds cannot be reverted back to a victim customer).

Remunerating a domestic CBDC generously, to compete with foreign monies, will exclude the possibility of enhancing central banks' seigniorage. Today seigniorage income comes from the fact that central banks earn interest income from interest-bearing assets, while having no interest costs on cash (which is a liability of a central bank). This can change if a generously remunerated CBDC substitutes cash. As also mentioned above, another downside with remuneration could be it being incompatible with anonymity (interest to be paid, the legal holder would probably need to be known). Yet, as argued by [OMFIF-IBM \(2019\)](#) smart contracts could be a possible future solution to this incompatibility issue. Generous remuneration of a domestic CBDC, while useful for customers at first, could also generate financial disintermediation and bank run issues, particularly during stressed times. If a CBDC is well remunerated, then those issues will require some other design features (discussed below).

While some think that full interoperability with foreign CBDCs (making it easy to switch) may give rise to more currency substitution, [Auer et al \(2021a\)](#) argues that, actually, fighting currency substitution may be more effective if a domestic CBDC is integrated into cross-border framework. However, this may mean more exposure to FX flows and exchange rate volatility. This could be problematic for emerging economies that were especially exposed to currency substitution in the first place. Programmability, meant to increase appeal of a domestic CBDC, may create cyber-risks if, for example, smart contracts will have to connect with external sources of information (so-called oracles). Oracles may be prone to more cyber-risks and, by extension, could hurt the CBDC system itself as well. This also creates reputational risks. In addition, offline functionality is very handy for customers, but (as discussed above) it is also prone to counterfeiting and double spending. However, it is

³⁶ This will strongly diverge between countries. As long as we have cash, lack of anonymity of other types of money (e.g. checking deposits) does not seem to bother people too much. This may change though if cash would disappear.

possible to have offline transactions with devices that periodically resynchronize with an online ledger.

3.1.2. Improving monetary transmission mechanism

The argument of CBDCs making monetary policy-makers' levers more potent (improving transmission mechanism) goes simply as follows: if a CBDC were interest bearing like other liquidity facilities at the central bank it could make transmission from policy rates to market rates faster. [Tobin \(1985\)](#) envisaged something similar (where he would "allow individuals to hold deposit accounts in the central bank"). If commercial banks were slow to adjust their deposit rates in response to a change in a policy (CBDC) rate, consumers could easily jump to CBDCs ([DNB, 2020](#)). Those consumers could include (institutional) investors that have lots of money to park but currently have no access to central bank balance sheet³⁷. However, improved transmission may be an important case for CBDCs only in countries with less developed financial systems. In case of advanced economies, the "degree to which key market rates move in conjunction with the policy rate appears satisfactory for most central banks" ([CPMI-MC, 2018](#)) already and it's not clear whether there's much to improve there ([Potter, 2017](#))³⁸. However, this could be very different in less developed systems, where central bank policy transmission to the rest of the financial system is much weaker. Yet, the counterargument to this could be that there are other more conventional tools that also help in strengthening monetary policy transmission ([CPMI-MC, 2018](#)).

In favor of this subsection's particular use case of a CBDC, [CPMI \(2015\)](#) mentions a potential problem (for central banks with monetary aggregate-based policy frameworks) created by a possible adoption of private digital currencies – monetary aggregates (that do not include private digital currencies) measurement error becoming larger. Having a CBDC may make monetary policy more effective in this environment if it competes with those private digital currencies. However, if stablecoins (that have a central bank money backing, or its near equivalent) are included later in the monetary aggregate measurement, this becomes less of an issue since private crypto-currencies are not widely used in the real world for payments anyway (due to price volatility and illiquidity). In addition, CBDCs can themselves also create difficulties in monetary operations. For instance, [CPMI-MC \(2018\)](#) underscores a point of autonomous factors becoming more volatile (conversion in and out of CBDCs) and, hence, liquidity forecasting – more prone to errors. Despite these possible drawbacks, [Bordo and Levin \(2017\)](#) and [Bordo \(2021\)](#), having this improved monetary transmission idea in mind, still argue that "the interest rate on CBDC could be used to foster true price stability by following a price level target following a Taylor type rule". [WEF \(2020\)](#) also considers the possibility to "improve monetary policy transmission and effectiveness" as one of the benefits of a possible retail CBDC.

³⁷ However, central banks may not allow this to happen, e.g. through quantitative limits on CBDC holdings.

³⁸ Unless one wants to fully eliminate effective lower bound on interest rates, which would require eliminating cash. However, a potential problem with deeply negative rates is a political economy one ([McAndrews, 2017](#)).

May require specific design choices:

Directly following from the above discussion, this benefit can only be realized if CBDCs are interest bearing, widely-accessible and without (much binding) limits on CBDC holdings, in line with [Bordo and Levin \(2017\)](#) and [Bordo \(2021\)](#). In addition, just like for the benefit in the above subsection, any design feature (e.g. privacy, programmability, finality, resilience against power outages, offline functionality) that makes a CBDC convenient instrument will help on this front as well. Having more users of a CBDC means better transmission of monetary policy.

Needed design choices may exclude other benefits or involve risks:

As also discussed in the previous subsection, a (close to) fully anonymous CBDC would make countering illicit activities (close to) impossible – needing a balance between privacy and some (minimum) amount of AML/CFT compliancy. Finality could also help, but it may exclude the benefit of improved customer protection (if funds cannot be reverted back to a victim customer). Remunerating a CBDC at market rates could hurt central banks' seigniorage. Also, remuneration of a CBDC could potentially be incompatible with anonymity (interest to be paid, the legal holder would probably need to be known). Worth noting that there could be ways to deal with this. For instance, the so-called zero knowledge proofs or secure multiparty computations may make it possible to accrue interest to a CBDC holder account without revealing the account balance ([WEF, 2020](#)), but identity may still be needed for tax purposes. In other words, unless those new technologies are utilized, the advantage of improving monetary transmission could exclude the benefit of more privacy/anonymity relative to, for example, current account deposits.

As mentioned above, programmability, meant to support CBDC take-up, may create cyber-risks (and, hence, reputational risks) related to oracles, which could be part of smart contracts and which are prone to more cyber-risks and, by extension, could hurt the CBDC system as well. In addition, while offline functionality may help CBDC take-up, it is also prone to counterfeiting and double spending, unless devices that conduct offline transactions are periodically resynchronized with an online ledger. More importantly though, and as also underlined above, full remuneration of a CBDC, meant to help take-up of a CBDC and improve monetary transmission, could also generate financial disintermediation and bank run risks (more details are in the next chapter about risks).

3.1.3. Seigniorage income

There are reasons to believe that an introduction of a CBDC may boost seigniorage income. For instance, by issuing a convenient digital currency that will compete to other (private or foreign public) currencies, central banks will be holding more interest-earning assets on their balance sheets. And if CBDCs (central banks liabilities) would not bear interest (or bear interest markedly lower than the market rate), then seigniorage income is boosted ([OMFIF-IBM, 2019](#)). As also mentioned by [CPMI \(2015\)](#), this is especially relevant if private digital currencies gain widespread adoption (at the expense of cash), which means that central banks non-interest bearing liabilities will decline, resulting in lower seigniorage. See also, [Adrian and Marcini-Griffoli \(2020\)](#).

May require specific design choices:

To make sure CBDCs increase seigniorage income³⁹, it shouldn't bear interest ([OMFIF-IBM, 2019](#)). Or to be more precise, the interest rate it bears should be non-positive⁴⁰. If the CBDC would be (positive) interest bearing, it would mean higher returns relative to physical cash (which has zero percent return) and, true, this is good news for money holders, but bad news for central bank seigniorage revenues. If central banks lose their own source of income, they would become more dependent on the fiscal side of a government, possibly exacerbating the political economy issues (like central bank independence).

Needed design choices may exclude other benefits or involve risks:

Since the mitigation of the risk of loss of seigniorage income requires no (or very low) remuneration of CBDCs, this may mean less ability of them to compete with other private or foreign public monies. In addition, (nearly) non-remunerated CBDCs would also not help on the front of improving monetary transmission. Also, seigniorage income will be boosted only if many people hold CBDCs. But this means more cyber-risks, as the central bank will be much more tempting target for cyber-criminals. As for costs, servicing this many customers and running payments systems can be extremely costly (unless outsourced), which would need to be more than counterbalanced by the seigniorage income. Finally, if take-up of CBDC is so large that it competes with banks' deposits it may cause financial disintermediation and increase bank run risks.

3.1.4. Dealing with effective lower bound on interest rates

[Bordo and Levin \(2017\)](#) make a forceful argument about CBDCs making true price stability possible (with zero inflation target), by eliminating an effective lower bound on interest rates, which, according to them, can be achieved by "facilitat[ing] the *gradual obsolescence of paper currency*" (emphasis of the authors). Eliminating an effective lower bound problem is indeed a considerable feat – it would make so much easier for central banks like ones in Europe or Japan to achieve their objectives. See also [Bordo \(2021\)](#), [Adrian and Marcini-Griffoli \(2020\)](#) or [CPMI-MC \(2018\)](#). More specifically, this could be helpful, since negative interest rates may provide a necessary boost to lending and economic activity during recessions, at least that's what the proponents argue ([Goodfriend, 2016](#), [Dyson and Hodgson, 2016](#)).

³⁹ However, we have to also keep in mind that, even if seigniorage income itself does increase, net marginal profit from introducing a CBDC may still be negative for a central bank if the costs of developing, implementing, running and protecting a payment system is high enough. Still, central banks may not take decisions solely based on that, because it is only a part of the picture (some benefits accrue to the general public not directly to the central bank).

⁴⁰ Positive (but lower than market rate) remuneration can also increase seigniorage if CBDCs compete mostly not with cash (which has zero interest rate) but with banks' term deposits (which pay higher and positive interest rate). However, this happening on a massive scale is unlikely, partly because central banks wouldn't probably allow it by respective design choices.

May require specific design choices:

[Bordo \(2021\)](#) notes that the elimination of the effective lower bound would require a CBDC being interest bearing. In addition, in this case a CBDC should substitute cash, not necessarily deposits. Hence, cash should be gradually discontinued by either not providing/printing it (which would be very unpopular if there still is demand for it), or by incentivizing people to voluntarily shift from cash to a CBDC. The former is very unlikely – for example, as stressed by the President of the Bundesbank, “the Eurosystem will continue to provide access to banknotes as long as people want cash” ([Weidmann, 2021](#)). Hence, if the latter approach is followed (CBDCs substituting cash voluntarily), then the CBDC should have features similar to cash (privacy, offline functionality, decentralization, retail).

Needed design choices may exclude other benefits or involve risks:

If remuneration is done at market rates, this would reduce central banks’ seigniorage. In addition, remuneration of a CBDC could potentially complicate achieving anonymity, if the latter is desired. On the other hand, anonymity or offline functionality like that of cash may make it difficult to remunerate a CBDC. Hence, there could be a trade-off even within an achievement of one single objective. Decentralization, unless remedied by new technologies, may contribute to scalability issues and reduce convenience.

Programmability may involve some cyber-risks, as mentioned above, through oracles. Offline functionality, which would be a feature similar to cash, may create double spending or counterfeiting problems. However, it’s possible to have offline transactions with devices that periodically resynchronize with an online ledger. Also, a combination of it being widely accessible (retail) and remunerated at market rates may lead to financial disintermediation and, potentially, bank run in a stressed scenario.

3.1.5. Making helicopter drops easier

Some argue that CBDCs may make helicopter drops easier to implement, even if they can already be done through fiscal policy distributing money via bank deposits or cheques ([OMFIF-IBM, 2019](#)). Relatedly, due to COVID-19, some central banks have altered their position regarding issuing a CBDC mostly because of its ability to be used “as a means of government-to-person payment, notably direct fiscal assistance or stimulus to households and small businesses” ([Boar and Wehrli, 2021a](#)).

May require specific design choices:

For this to work, according to [Group of Central Banks \(2020\)](#), it would be required to have a “CBDC system with identified users (eg a system linked to a national digital identity scheme)”. Clearly, a CBDC would also need to be retail so that the received money can be spent on a CBDC infrastructure. Having no (or relatively mild) quantitative limits on CBDC holdings may also be required in some (probably few but still) cases, where those who have a CBDC

account but not a bank deposit account⁴¹ are still technically able to receive money without hitting the ceiling.

Needed design choices may exclude other benefits or involve risks:

The major issue here seems to be excluding the benefit of sufficient privacy - if users would have accounts (with user identification), this (with current technologies) seems to rule out the possibility of having anonymity similar to cash. These helicopter drops (or an expectation of it happening) may lead people to switch to a CBDC at the expense of cash. Hence, a possibility of anonymous payments (done with cash) may become almost non-existent. In other words, with fiscal transfers in mind, retail CBDC may lead to a significant take-up, potentially generating some financial disintermediation, if depositary institutions would be forced to answer by increasing (deposit) interest rates. Hence, privacy could suffer with fully user-identified accounts and big enough take-up (which is possible because of a retail approach with less stringent or no quantitative limits of CBDC holdings) that may drive cash out of payment systems.

In addition, as noted by [Group of Central Banks \(2020\)](#), “if fiscal transfers were made with CBDC there is a risk of blurring the division between monetary and fiscal policy and a potential reduction in monetary policy independence”. While we should also note that helicopter money always has been a combination of fiscal and monetary policies, that’s probably the reason why it’s not an approach usually used by countries (i.e. “blurring the division” argument).

3.2. Financial stability

In the literature, it has been frequently argued that while an introduction of a CBDC may be useful for payment convenience (cheap, easy, fast), it can also be risky for financial stability. But as it turns out, and also emphasized by many authors as well, a CBDC can itself be beneficial for financial stability as well through a number of channels. These channels are discussed below, starting with the possibility of reducing a financial stability risk related to systemic disruptions in payment systems.

3.2.1. Stability of payment systems

Systemic risk of payment systems comes from their central role in current economic relationships. Indeed, [Chen et al \(2020\)](#) show that suspending payments temporarily can have a substantial impact on macro-financial stability. This risk is particularly aggravated if we have one particularly big player. What central banks can do here is to ensure level playing field so that competition is achieved in payments market (not ending up with one big private player), where CBDCs could be helpful. A dominant player exposes the system to a “single point of failure” problem. This is a real possibility: BigTech and FinTech firms may not only have those features that traditional networks have (like network externalities or economies

⁴¹ Having a CBDC account but not a deposit account would make it impossible to follow an overflow approach, where “funds in excess of a cap could be transferred automatically to a linked commercial bank deposit account” ([BIS, 2021a](#)).

of scale and scope), but they could also be much more cost-efficient and able to utilize their bigger datasets in their own favor ([BIS, 2020a](#)). If these firms pick up sufficient number of customers, they could become entrenched – threatening the financial stability by becoming too important to fail. [Weidmann \(2021\)](#) discusses similar “self-reinforcing loops and ‘lock-in’ effects”, which “may tie users to one platform and exclude competitors”. CBDC may be able to address this problem by providing the public infrastructure that ensures interoperability, safety and level playing field for competition ([BIS, 2020a](#)). CBDCs being able to break through or avoid formation of private fragmented closed-loop payment systems is also emphasized by [Group of Central Banks \(2020\)](#). Central banks can also promote competition by incentivizing participation of non-bank Payment Service Providers (PSPs) or FinTechs. This can be achieved by making them eligible for central bank operations⁴² (e.g. [SNB, 2019](#)).

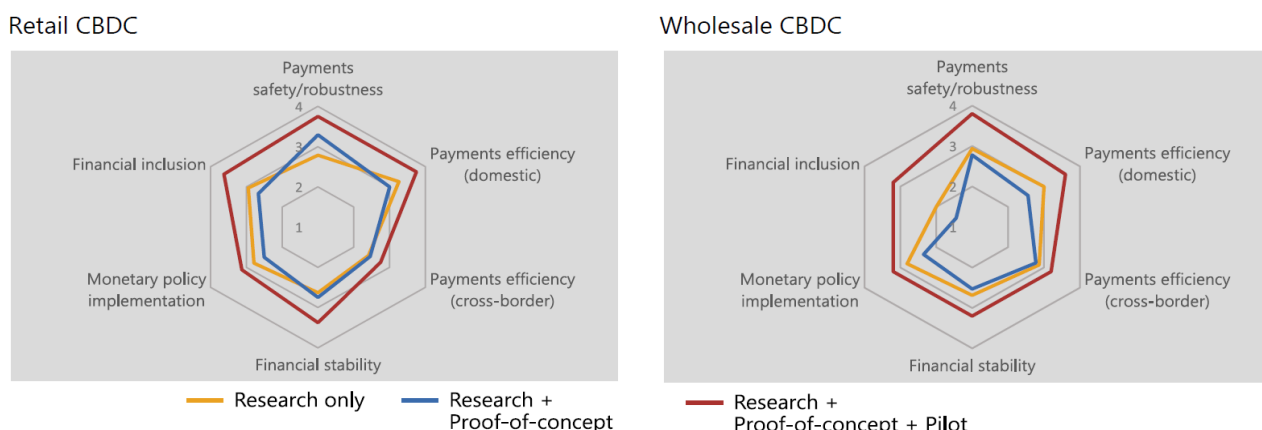
[CPMI-MC \(2018\)](#) envisages a potential benefit of a CBDC along those lines. [OMFIF-IBM \(2019\)](#) also reports that central banks take this threat – “fragmentation of the payments landscape and entrenchment of market power” – seriously. That’s why 69% of central banks surveyed by them says that providing an alternative (competitive) digital means of payment is their main motivation. Put differently, a CBDC could be a contingency solution if other payment systems fail. Of course, there are some common factors that may shut all the systems down simultaneously (e.g. country-wide power outage or failing communication systems), but as far as single points of failure issue goes, having a contingency system can still be useful sometimes. See also [DNB \(2020\)](#). Even more forceful is the argument of [Schnabel and Shin \(2018\)](#) – after discussing the origins of early precursors of contemporary central banks, they actually argue that the central banks original function was to provide a stable payments system, even if this contrasts with the widely-held and in most cases convincing view that central banks were created to finance wars (e.g. [Goodhart, 1988](#))⁴³. [Adrian and Marcini-Griffoli \(2020b\)](#), [Lagarde \(2020\)](#) and [WEF \(2020\)](#) contain a related discussion.

In fact, stability of payment systems is what central banks think is a key benefit of a CBDC. What’s more striking is that *after* central banks develop proofs-of-concept or implement pilots, they assign much more weight on the importance of payment system stability ([Boar and Wehrli, 2021a](#)). This, among other motivations for central banks, is shown on the graph below.

⁴² However, the downside of this is that those non-banks may be more risky due to them being regulated less stringently.

⁴³ At least in case of Bank of England, as a matter of fact, it was created to finance war with France. The role of provision of a private payment system was introduced later. The Dutch central bank (DNB) was established to promote financing of industry in 1816. It became only the official central bank in 1952, although it already operated as LOLR. However, this doesn’t downplay the importance of payment systems’ stability.

Figure 2 – Importance of different CBDC motivations perceived by central banks



(1) = "Not so important"; (2) = "Somewhat important"; (3) = "Important"; (4) = "Very important".

Source: [Boar and Wehrl \(2021a\)](#)

May require specific design choices:

Promoting competition may require the central bank to be the operator of the basic CBDC infrastructure ([BIS, 2020a](#)). Private sector would have an access to this infrastructure through different channels, including Application Programming Interfaces (APIs). While central banks operating such basic part of the payment system may promote competition (many private agents being able to connect through APIs), this may also increase technological risks. Central banks' (basic) infrastructure would become all the more important target for cyber-criminals. How can this be remedied is a technological topic that needs to be addressed. For example, more resilience to cyber attacks could potentially be achieved with "the use of DLT in a primary or back-up domestic interbank payment and settlement system" ([Lannquist, 2019](#)). One can also think of several independent data centers containing a copy of a ledger to increase the resilience.

Needed design choices may exclude other benefits or involve risks:

Decentralization (meant to increase resilience) may theoretically create some hurdles in terms of scalability (depending on CBDC take-up). In that case, a CBDC may not achieve the aim of increasing convenience of payments for consumers and merchants. As mentioned above, technological risks may turn out much more important in response to more cyber-attacks. Decentralization may lessen this issue, but it remains to be seen how much does it eliminate this altogether.

3.2.2. Continued existence of outside money

As the survey by [OMFIF-IBM \(2019\)](#) shows, central banks are worried that if cash does disappear, then without the access to risk-free universally accepted medium of exchange, the confidence in the financial system may become undermined, especially during crises. This is the topic also emphasized by [Armelius et al \(2020\)](#) or [Panetta \(2021b\)](#). In the words of the latter, confidence in bank deposits or "private money is largely determined... by the *promise* of one-to-one convertibility with risk-free central bank money" (emphasis of the author). As [DNB \(2020\)](#) puts it "users see a euro amount as a euro amount, regardless of whether that is

an amount in a bank account, a banknote or a handful of coins. This fungibility has become so commonplace that many people take it for granted”. But we shouldn’t. If the link (call it a “fixed exchange rate”) between public and private monies suddenly breaks down, financial stability concerns may arise. For instance, during heightened uncertainty demand for public money increases ([Jobst and Stix, 2017](#)) and the failure to satisfy this demand may result in a financial panic.⁴⁴

[Lannquist \(2019\)](#) also emphasizes a similar point in somewhat different words: CBDCs may be important “to offer retail depositors a safer savings venue (i.e., accounts with the central bank) with lower risk of default or loss of funds than storing savings in domestic commercial bank accounts (varies by country)”. However, if a massive CBDC take-up is what central banks would want is a different story. [CPMI-MC \(2018\)](#) argues that, where cash is disappearing, retail CBDC as an access to a central bank money for wider population may bring “substantial benefits”. However, analyzing other means of doing the same is also advisable (e.g. if fast and efficient private retail payments are already in place). See [WEF \(2020\)](#) or [Group of Central Banks \(2020\)](#) for a related discussion. In this digital world, [Usher et al \(2021\)](#) also underscores the importance of having an online outside money as people switch to online commerce over time.

May require specific design choices:

The importance of having a CBDC as an outside money is only high when and if cash disappears. But if a CBDC is to replace cash, even though most central banks hold the view that it should be an addition to cash, then it should be widely-accessible and have no quantitative limits, since this would violate the one-to-one convertibility (fungibility) promise. See the related discussion in the previous section about design principles (subsection 2.6 Quantitative limits).

Needed design choices may exclude other benefits or involve risks:

Since the key requirement for this advantage to be possible is merely an existence of a CBDC (albeit with not much quantitative limits which may involve costs but do not exclude other benefits), achieving this particular task/benefit isn’t at odds with other benefits.

Cybersecurity risks are the key risk. Failure of the platform could easily be a source of a messy systemic crisis. The same isn’t true for cash ([WEF, 2020](#)), which is why cash will most likely not disappear, neither from a supply (central bank) side, nor from a (public) demand side, at least until the perception of even a small probability of significant cyber-risks exists. In addition, having no quantitative limits in a retail CBDC may mean some financial disintermediation and bank run risks. A resulting possible cost is also a larger state footprint in credit allocation, if central banks try to remedy the financial disintermediation risk by providing very large amounts of liquidity in the system against more risky assets as collateral

⁴⁴ Limiting an access to a public money may also help to calm down the bank run. For instance, in Greece, during the crisis, the amount that people could change from deposit money into cash was limited and it helped to retain confidence in the banking system. However, following this approach indefinitely can still shake the confidence in private (deposit) money *in general*.

(since risk-free assets are sometimes scarce) – see the discussion in the respective subsection below.

3.2.3. Fighting currency substitution (competing with foreign e-moneys)

Fighting currency substitution (financial dollarization) is a possible benefit of a CBDC that we have already covered in monetary policy section. However, the same applies to a financial stability side – reducing currency substitution / dollarization reduces systemic risks. Currency substitution can take the form of advanced country currencies (e.g. USD) or stablecoins. For instance, [G7 \(2019\)](#) discusses the wide-array of possible risks that global stablecoins entail, especially related to systemic risk and financial stability. Given the possibility of those stablecoins or foreign CBDCs becoming a dominant means of payment in the future (fueling domestic currency substitution), this may, at some point, become a cause of concern, especially if risk-proportionate regulation is not rolled out. An alternative is to try to avoid those risks by offering a somewhat similar (digital) alternative in the form of a domestic CBDC, where, in principle, the public will have more control of the risk-taking and the design. [Adrian and Marcini-Griffoli \(2020\)](#) also discusses a similar point among many other authors.

This could be particularly important during economic downturns, when there's an increased demand for US dollar banknotes (which could potentially be digital ones) in countries with inferior currencies, as emphasized by [Ruth Judson](#) in the review of [Gnan and Masciandaro \(2018\)](#). Since the reasoning of how a CBDC may help is the same as in the monetary policy section, we do not reiterate them here. Just worth noting that the benefit of fighting currency substitution in the context of CBDCs has been underlined by many. [Adrian and Marcini-Griffoli \(2020b\)](#), [Brunnermeier et al \(2020\)](#), [OMFIF-IBM \(2019\)](#), [DNB \(2020\)](#), [WEF \(2020\)](#), [Group of Central Banks \(2020\)](#) and [Auer et al \(2021a\)](#) is just a selective list of such papers.

May require specific design choices:

As also mentioned above, design features that increase an appeal of a domestic CBDC will help on the currency substitution front. This includes privacy, programmability, finality, resilience against power outages (possibly through decentralized systems) and possibility of offline functionality as well as remunerated at a rate close to market rates.

Needed design choices may exclude other benefits or involve risks:

Finality is a very customer-appealing feature, but may exclude the benefit of improved customer protection (if funds cannot be reverted back to a victim customer). In addition, generous remuneration of a domestic CBDC will hurt on central banks' seigniorage side. As also mentioned above, remuneration could also be incompatible with anonymity (interest to be paid or for interest income tax purposes, the legal holder would probably need to be known).

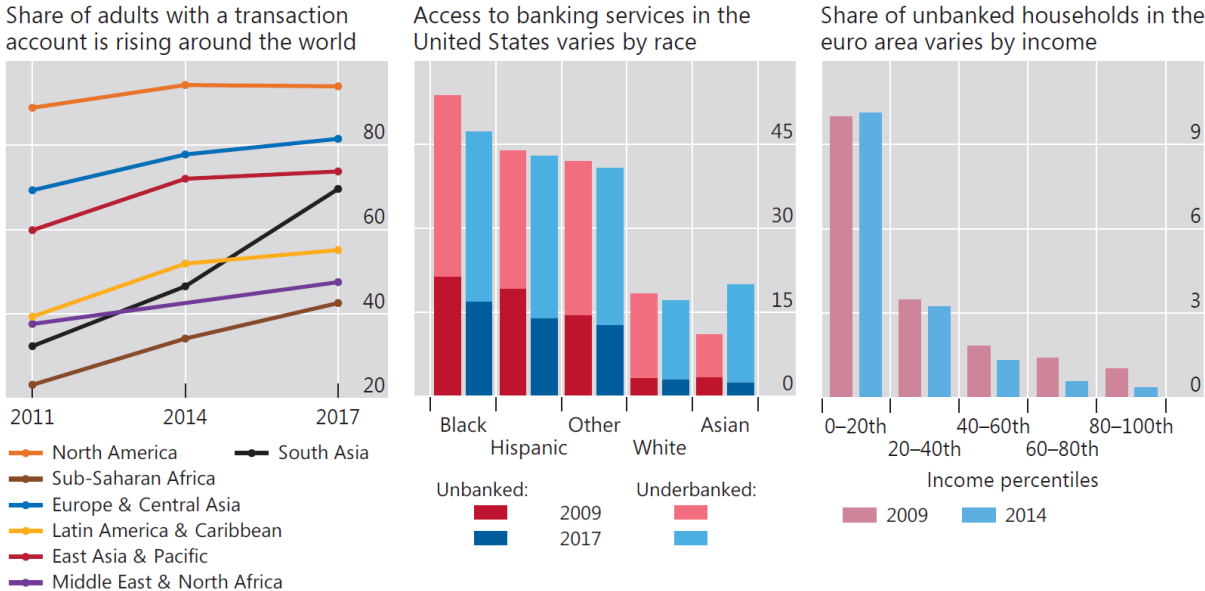
According to [Auer et al \(2021a\)](#), fighting currency substitution may be more effective if a domestic CBDC is integrated into cross-border framework, which may generate more FX flows and exchange rate volatility – frequently problematic for emerging economies that may have suffered from dollarization in the first place. Programmability (also consumer-appealing feature if properly implemented) may create cyber-risks as well as reputational risks, again,

through oracles. In addition, while offline functionality is very appealing for customers, it is also prone to counterfeiting and double spending, at least unless offline transactions with devices are periodically resynchronized with an online ledger. Finally, generous (market-rate) remuneration of a domestic CBDC, while appealing, could generate financial disintermediation costs, higher bank run risks in stressed times and, potentially, larger footprint of the state in credit allocation.

3.2.4. Financial inclusion

Financial inclusion is something that’s on central banks’ radars as well. Partly because this is a societal goal (but maybe more relevant for a government?) and partly because it also has a direct implication for financial stability (with a link between financial inclusion and financial stability being a positive one according to [Morgan and Pontines, 2014](#)). CBDCs have a lot of room in this sense. There are 1.7 billion adults and hundreds of millions of firms globally that lack transaction accounts and it’s low-income households, women and small businesses that bear the brunt ([BIS, 2020a](#) or [Demirguc-Kunt et al, 2018](#)). This is well shown on Figure 3. Even if financial inclusion may not be an important motivation for advanced economies, it is for most of emerging market central banks ([OMFIF-IBM, 2019](#)). This point is made clear by the World Bank Findex database which shows that in the developing economies only 63% of the population had an account with a financial institution or a mobile money service in 2017 ([Demirguc-Kunt et al, 2018](#)). Clearly, for a CBDC to foster financial inclusion, it should address, if possible, the issues that made unbanked people unbanked (e.g. trust in issuer, cost, necessity of technological ability, etc.). As [OMFIF-IBM \(2019\)](#) argues, CBDC’s “[b]enefits for financial inclusion may be extraordinary”, if properly designed.

Figure 3 – Financial inclusion in numbers



Source: [BIS \(2020a\)](#)

In addition, COVID-19 pandemic has shown us how vulnerable unbanked population is. Given they cannot use cash for online shopping, this puts them into a difficult place. For this reason, some central banks even urged merchants to continue accepting cash ([Bank of Canada, 2020](#)

or [Reserve Bank of New Zealand, 2020](#)). One may argue that financial inclusion is something linked to countries income levels (see Figure 3 for distinguishing between countries with and without high degree of financial sophistication), but as the evidence suggests you can leapfrog and improve it even in low-income and emerging countries by adopting digital (real-time) platforms ([D’Silva et al, 2019](#)). See also [Adrian and Marcini-Griffoli \(2020b\)](#), [Lannquist \(2019\)](#), [CPMI-MC \(2018\)](#) or [Bordo \(2021\)](#) for a related discussion about CBDCs and financial inclusion.

May require specific design choices:

For CBDCs to be able to deal with financial exclusion, it must deal with its underlying causes. According to [Group of Central Banks \(2020\)](#) financial exclusion may be a result of, for instance, providing payment services to some segments of the population not being commercially profitable enough, especially relevant in thinly-populated areas, costs of payment services being too high or those segments of the population not trusting the payment service providers (e.g. banks). In terms of a CBDC-related public infrastructure it is easier for central banks to promote digital identity (ID) systems, that can help reduce onboarding costs and enhance financial inclusion ([Ehrentraud et al, 2020](#)). Public and private sectors working side-by-side is particularly capable in this sense ([Carr et al, 2020](#)). For instance, [D’Silva et al \(2019\)](#) shows how such a combination in India led to a significant improvement in terms of financial inclusion, by lowering costs of opening accounts and bringing unbanked into formal financial system. This means no fees for obtaining a CBDC wallet/account and it being widely-accessible (retail).

Needed design choices may exclude other benefits or involve risks:

Like in case of a CBDC providing a back-up system in the form of outside money, here as well, a mere existence of a low-cost CBDC may be sufficient. Hence, achieving financial inclusion benefit isn’t, in and of itself, at odds with other potential benefits of a CBDC. The only tricky case is when a central bank wishes to give people access to CBDCs without the private sector involvement – a direct approach, which does incorporate significant risks (e.g. threat to monetary policy independence).

As always, cyber-threat is a risk worth analyzing from the outset. Another key issue (not as much of a risk, but a cost) is the cost of operating a CBDC infrastructure – for it to be low-cost for unbanked households, someone should bear the costs. Since we can’t force the private sector to expend these cost, it seems that a central bank / government will need to be paying the bill.

3.2.5. Smaller informal economy

Digital payments support a reduction in the share of informal economy ([BIS, 2020a](#)), probably only if a CBDC substitutes cash. This is an upside for financial stability, as creating digital record of transactions and formal economic history will allow financial intermediaries take more calculated risks (i.e. pursue financial deepening without much risk-taking)⁴⁵. With rising

⁴⁵ More effective tax collection is another related point.

demand for digital currencies in digital economies, unless a domestic CBDC is issued, usage of a foreign CBDC could rise, potentially facilitating tax avoidance (see [Auer et al, 2021a](#)).

May require specific design choices:

Pushing people into a formal economy will not be possible with an anonymous design. Also, a CBDC would need to be widely adopted, i.e. retail and otherwise attractive similar to cash (some offline functionality, instant, with not much fees). Programmability could also be an additional way to lure in cash holders.

Needed design choices may exclude other benefits or involve risks:

Clearly, for a CBDC to reduce the size of informal economy and tax evasion, full anonymity in digital payments would need to be sacrificed. Hopefully, emerging technologies would make it possible for a CBDC to at least allow some form of privacy, even if not anonymity.

Key problems in terms of design features needed to achieve a reduction in the share of an informal economy are technological risks, as always, and privacy concerns. Even the very communication of this kind of an aim from authorities (which makes it clear that at least some information on all transactions would end up in a treasury / ministry of finance) may make a CBDC so unappealing that the authorities may not even be able to achieve a smaller informal economy. Here, communication of intentions can be crucial.

3.2.6. Lower counterparty risk

Programmable money has a potential to reduce counterparty risk by using atomic cross chain transactions ([Ali and Narula, 2019](#)), where all of the transactions included will need to be settled together⁴⁶. As counterparty risk is a potentially important part of overall financial stability, reducing it could be beneficial for financial resilience. [WEF \(2020\)](#) also notes this potential benefit (of lowering counterparty risk), but argue that there's not much value added domestically, as domestic interbank payments are already efficient. In case of cross-border transactions, things could be different. See also [CPMI-MC \(2018\)](#).

May require specific design choices:

The distributed ledger technology is capable of providing atomic transactions. In the words of [Lannquist \(2019\)](#), in "a 'delivery versus payment' transaction, the full and final payment and settlement for a trade occurs at the same time the asset is fully (or 'atomically') delivered to the buyer. Both the asset and currency are located on the distributed ledger and they are traded simultaneously. The result is greater operational efficiency and reduced settlement and counter-party risk". As [Ali and Narula \(2019\)](#) note, even if "the asset was not blockchain-native... this would still reduce risk on the part of the person on the side of the swap collecting cryptocurrency and it provides a useful interface".

According to [WEF \(2020\)](#), true, this type of atomic transactions does not necessarily require the usage of the distributed ledger technology, instead they depend on "conditional

⁴⁶ Although there is also an ethical side to programmable money. For example, it opens the opportunity for the government to issue social security allowances with pre-programmed conditions.

programming and general-purpose hash functions”. But despite this, DLT may offer other benefits when using with smart contracts that “could enable certain benefits such as automated and transparent escrow accounts for participants that reduce the need for intermediaries such as clearing houses or custodians to guarantee and deliver funds in exchange for assets”. As argued by [Balz \(2020\)](#), smart contracts may not even require an introduction of a CBDC, as there “could be a technical connection between a smart contract and TARGET2, where the smart contract initiates or rather triggers a payment in TARGET2”⁴⁷.

Needed design choices may exclude other benefits or involve risks:

Convenience may get hit, if in a distributed ledger technology a decentralized consensus protocol is such that processing large numbers of transaction in a short period of time is infeasible. What happens if a wrong counterparty transaction is included in the blockchain is another issue that needs to be clarified. There may not be many other explicit risks emanating strictly just from a usage of a DLT, but costs of an infrastructure and technological risks are noteworthy. In addition, in a permissioned DLT “designated validators verify transactions and update the ledger at a cost that is derived from a supermajority voting rule. Without giving proper incentives to validators, however, their records cannot be trusted because they cannot commit to verifying trades – thus giving rise to a public good provision game – and they can accept bribes to incorrectly validate histories” ([Auer et al, 2021b](#)).

3.2.7. More information for regulators

[Monnet and Keister \(forthcoming\)](#) argue that granular information flows from account-based CBDCs give financial regulators better view of current financial situation of banks and, hence, may make them better equipped to fight the problem at the outset before it turns into a full-blown crisis. However, the question is whether this is only an incremental change – central banks already have a perfect information about the amount of liquidity in the system and whether or not banks have good collateral. See also [WEF \(2020\)](#) and [CPMI-MC \(2018\)](#).

May require specific design choices:

In addition to being non-anonymous (account-based, but possibly just wholesale), this requires that the CBDC’s remuneration not be too generous, to make sure it flows more actively.

Needed design choices may exclude other benefits or involve risks:

Clearly, anonymity won’t be achieved if a CBDC is aimed at more information for regulators. Non-generous remuneration may not be sufficient to make a CBDC compete with foreign currencies (fight dollarization). [WEF \(2020\)](#) also notes that this extra information comes with an extra need for cybersecurity and resilience to counter the heightened risks.

⁴⁷ TARGET2 is the real-time gross settlement (RTGS) system owned and operated by the Eurosystem.

3.3. Payment systems

A payment system, as defined by [BIS \(2020a\)](#), is a “set of instruments, procedures and rules” that make it possible for households and businesses to move funds around – making and receiving payments. Efficient and well-functional payment systems are a significant determinant of a long-run economic growth ([Humphrey et al, 2006](#) or [Levine, 2005](#)). How good a payment system is can broadly be measured by costs of its operation as well as benefits in terms of costs they help us save upon. In this subsection we concentrate on the latter – i.e. implications in terms of benefits disrupted payment systems can provide. One thing we need to have in mind when comparing existing payment systems with a new potential one associated with a CBDC, is that today’s payment system operates within a two-tier system comprising of private as well as public monies⁴⁸ ([BIS, 2020a](#)). Hence, what the CBDC changes depends on whether it competes with one or the other (or both).

3.3.1. Convenience

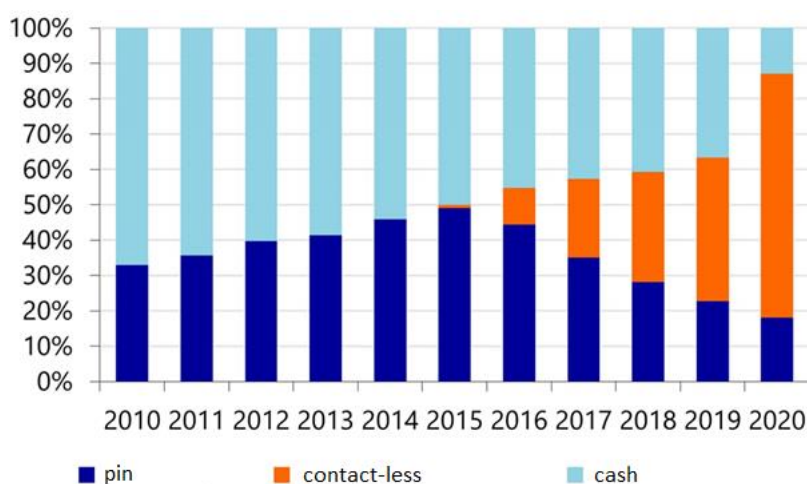
Convenience in everyday transactions is important for consumers, because those transactions are performed so frequently. For instance, according to [ECB \(2020\)](#) each of the adult population of the euro area made two transactions per day on average in 2019, including using cash. Use of cash, however, can be quite inconvenient: both parties of a transaction need to be physically present, cash must be physically stored (that is costly), there’s a risk of counterfeit and its very impractical for large-value transactions ([OMFIF-IBM, 2019](#))⁴⁹.

Convenience of digital payments (like payments with CBDCs), on the other hand, is particularly apparent during periods when there’s an epidemic that requires strict social distancing rules. In addition, rightly or wrongly, people may fear the virus transmission from cash and seek a refuge to digital forms of money. For instance, [Garratt et al \(2020b\)](#) estimate, using a simple model of Google searches, the effect of COVID-19 pandemic on peoples payment behaviour and finds that “at the maximum difference, searches regarding payment apps were 42 percent higher, and searches with the keywords “ATM near me” were 42 percent lower, than projected using our model”.

⁴⁸ With private money being the front-liner (consumer-facing) and public money being the trust-insurer.

⁴⁹ Though, it also has benefits – it is settled in real-time and is irrevocable. It also has the highest degree of privacy.

Figure 4 – Contact-less payments taking off (Netherlands, % of total over-the-counter transactions)



Source: Rabobank, Payments Association Netherlands

This shift from cash to digital channels may prove to become long-lasting, as people form a habit of paying digitally. In the Netherlands, for instance, we see a strong rise of contactless payments, which has accelerated during the COVID-19. The share of cash is declining structurally, but especially the traditional debit card transactions (using pin codes) have declined rapidly since 2015 (see Figure 4). See also [Group of Central Banks \(2021b\)](#) which discusses user needs (including convenience) that a CBDC would be required to satisfy.

Yet [CPMI-MC \(2018\)](#) claims that this benefit may not be a very strong rationale for a CBDC introduction, because in many cases, current private retail payment solutions are already “convenient, efficient and reliable, and have earned public trust and confidence over time”. In the future these existing systems may get even better, but one exception may be “cross-border retail payments, which are generally slower, less transparent and more expensive than domestic retail payments”.

May require specific design choices:

One of the key requirements for convenience is the speed of transaction execution. If this requirement is applied on a massive scale, the scalability may become an issue for decentralized systems, depending on a new technology used. In that case, centralized approach may be warranted for this particular benefit to materialize. Also, finality is a useful feature for users (see [BIS, 2020a](#)), which may not be possible with probabilistic finality of specific consensus protocols in a decentralized system. In addition, [Group of Central Banks \(2021b\)](#) underlines the importance of offline functionality (at least temporary, where “internet availability is limited or unreliable”) and privacy as well as reduced costs/fees. But here, “decentralised ledger could have the potential to make peer-to-peer and offline payments easier” ([Group of Central Banks, 2020](#)).

Needed design choices may exclude other benefits or involve risks:

As always, if decentralised approach is chosen, new technology risks need to be weighed. [Saunders \(2019\)](#) also considers the risk of consumer protection issues if a CBDC is too fast. Namely, a fraudulent transaction that is final (irreversible at the moment of initiation) may

hurt consumers that do not pay big enough attention to details of the transaction. In addition, “improving user convenience by making offline and peer-to-peer payments possible would necessitate additional safeguards to counter the risk of fraud, since security features and centralised controls (eg to ‘lock’ stolen funds or query suspicious transactions) are more difficult to implement on a distributed system” ([Group of Central Banks, 2020](#)).

3.3.2. Anonymity/privacy in digital payments

Full anonymity may be something almost impossible in the digital age (even the permissionless Bitcoin is only pseudonymous), but there are ways that get close enough. The issue, though, would be AML/CFT problems would multiply. For this reason, that approach is probably not going to be pursued from authorities around the world. However, it is still possible to ensure third-party privacy (that is indeed different from anonymity), while making sure that movement of money is still stored somewhere, e.g. in the private sector, and can be accessed if necessary, e.g. based on a court decision suspecting money laundering or alike ([OMFIF-IBM, 2019](#)). This means that CBDCs may do a reasonable job at both privacy as well as complying with AML/CFT regulations. See also [BIS \(2020a\)](#) or [Group of Central Banks \(2020\)](#). While this middle ground is usually something that most institutions or authors argue in favor of, [Gladstein \(2021\)](#), among others, forcefully argues in favor of fully anonymous CBDC as a means for customers to avoid state censorship.

May require specific design choices:

Obviously, for achieving something close to full anonymity, a CBDC (clearly, a retail one) would need to be based on a decentralized system. If instead, third-party privacy is called for, then payment data should be stored at some place, which is usually private payment providers (banks). In this case, an intermediated CBDC approach would be needed, instead of a direct one.

Needed design choices may exclude other benefits or involve risks:

Consumer protection may become more problematic with anonymous digital payments ([Saunders, 2019](#)). Also, as emphasized by [Walter Engert and Ben Fung](#) in the review of [Gnan and Masciandaro \(2018\)](#), anonymity may complicate or even exclude the possibility of paying interest on a CBDC. Namely, “[f]or income tax purposes, the central bank (at least in Canada) would be required to provide information about the identity of the recipient of interest income to tax authorities, and to withhold tax on interest income credited to non-resident holders of CBDC.” In addition, according to [BIS \(2021a\)](#), an anonymous token-based system may not be “compatible with the monitoring of illicit activity in a payment system”. Finally, restricting access to domestic agents’ use cases will be impossible with anonymous CBDCs, unless a new technology is used. “If the technology also allows the use of CBDC to be tied to a specific location, one option is to allow the use of CBDC by non-residents as long as they are physically located within the issuing jurisdiction. This approach is being considered by the People’s Bank of China (PBC) for its electronic Chinese yuan (e-CNY) project” (see [Auer et al, 2021a](#)).

3.3.3. Reducing cost of cash

Introducing a CBDC may help central banks or private players save upon big costs of cash infrastructure ([Adrian and Marcini-Griffoli, 2020b](#)). As argued by [OMFIF-IBM \(2019\)](#), while the introduction of a CBDC involves significant costs, the resulting efficiency gains (because of very low marginal costs) will far outweigh the costs of the introduction. According to one respondent in that report “[i]f a [retail] CBDC is implemented the cost will be lower compared to cash management”. Estimates of social and private costs of cash distribution and maintenance can be as high as a full percent of GDP in some cases ([Junius et al, 2022](#)). A CBDC infrastructure seems to be more efficient than that, despite other costs (like cybersecurity staff payroll and compliance costs). CBDCs also help merchants reduce costs of cash handling as well as households save time necessary for withdrawals from ATMs or bank branches. For a related discussion see also [Lannquist \(2019\)](#), [WEF \(2020\)](#) or [Bordo \(2021\)](#).

May require specific design choices:

Worth noting though that, while digital distribution of money may indeed be cheaper than physical distribution of cash ([DNB, 2020](#)), the validity of this statement also depends on the design – central banks being sole payment operators could result in massive costs. Hence, a hybrid or intermediated CBDC solution might be more cost-effective, as public and private actors will be playing to their strengths⁵⁰. Obviously, it should be a retail system for public-wide take-up to happen. Also, features that resemble cash (offline functionality, instant, privacy-preserving, etc.) will make it more probable that the CBDC substitutes cash.

Needed design choices may exclude other benefits or involve risks:

As in previous cases, consumer protection issues should be considered in a system with finality and offline / peer-to-peer payments. E.g. see [Saunders \(2019\)](#) or [Group of Central Banks \(2020\)](#).

3.3.4. Reducing transaction costs

While the previous subsection was about minimizing wholesale costs of maintaining cash architecture (printing, distribution, handling), another (but related) point is the reduction of costs on the retail level, e.g. households having to pay smaller transaction fees. As noted by [BIS \(2021a\)](#), “[d]espite decades of ever-accelerating technological progress, which has drastically reduced the price of communication equipment and bandwidth, the cost of conventional digital payment options such as credit and debit cards remains high, and still exceeds that of cash... In some regions, revenues deriving from credit card fees are more than 1% of GDP... The concern is that when big tech firms enter the payments market, their access to user data from associated digital business lines may allow them to achieve a dominant position, leading to fees that are even higher than those charged by credit and debit card companies currently. Merchant fees as high as 4% have been reported in some cases”.

⁵⁰ The precondition is, of course, that banks can use their existing infrastructure for their gatekeeper role for CBDC transactions. If this is not the case, their costs may also be very high.

Transaction fees for payment system consumers can be quite high today, partly because of related costs, but partly also because of market power, even though they may already be facing stiff competition from new FinTech firms ([McKinsey & Company, 2019](#)). Hence, CBDC can be an additional force to use that potential of lowering transaction fees, both through technology (lower costs) as well as competition (profit margins) without hurting the long-term survival of payment systems and economic growth ([BIS, 2020a](#)). What is even more important, the same evidence shows that these existing fees are regressive (proportionately more costly for low-income users).

May require specific design choices:

A retail CBDC should be with either a conventional centralized infrastructure or a cost-efficient DLT alternative so that verifying transactions does not involve too much costs (which would be transferred to consumers one way or another). In theory, a mere existence of a low-cost CBDC can create a competitive environment for private players to either cut costs (technology side) or reduce profit margins on payment services (competition side).

Needed design choices may exclude other benefits or involve risks:

[WEF \(2020\)](#) also underlines this benefit but argues that the flip side is the possible credit disintermediation as well as risk of digital bank runs. Namely, a big enough portion of banks' funding comes from the fact that deposits (i.e. private money) have transactional nature (i.e. liquidity premium). But if this is disrupted by a competing CBDC, it could reduce this source of funding for banks.

3.3.5. Facilitate cross-border payments

CBDCs can play an important role in improving the cross-border payment systems ([Bech and Hancock, 2020](#)). These type of payments usually take days to settle ([CPMI, 2018b](#)). In addition, cross-border payments (especially cash transfers) suffer from the same problems as described above, but in even more severe form: high costs (lack of proper technology) as well as high profit margins (lack of competition). Here again, it is low-value transactions that incur the highest costs ([CPMI, 2018b](#)) and it is poorer countries that are hit the hardest ([Rice et al, 2020](#)). In the first quarter of 2020, the global average cost of sending \$200 was 6.8%, while it was even higher during the year before ([World Bank, 2020](#)). This is just too big a number for a transaction cost. Lowering this cost would help low- and middle-income countries the most, since, according to the World Bank data, these countries receive more than three quarters of remittances globally. Remittances are one of the most important sources of a foreign currency and aggregate demand in some countries.

Many central banks (62% of respondents surveyed by [OMFIF-IBM, 2019](#)) think that CBDC development in different countries may make cross-border payments much more efficient. This can be achieved through making different country CBDCs interoperable, reducing the reliance on correspondent banking. The only thing required, in case of interoperable CBDCs of any two currencies, would be an (possibly implicit) exchange market across those currencies. But for the benefits (affordability, speed) to be the highest, entry into this market should be easy (i.e. high enough competition). Hence, the key problem with the CBDC's contribution to improving cross-border payments could be a lack of cooperation on a technology side. But recent news may be more promising in this regard ([BIS, 2020b](#)). As [BIS](#)

(2021a) puts it, multi-CBDC “arrangements would allow central banks to mitigate many of today’s frictions by starting from a ‘clean slate’, unburdened by legacy arrangements”. In terms of a question of why only private players’ involvement may not be sufficient, [Bofinger and Haas \(2020\)](#) argue that, from microeconomic or market failure perspective, there’s a strong rationale for CBDCs being used for global payments. But this would require a supranational approach.

In general, there are two basic ways for CBDCs to facilitate cross-border payments: (1) allowing foreigners to hold a CBDC even abroad (retail approach) and (2) designing a framework that would interlink different country CBDCs (wholesale approach). E.g. see [Auer et al \(2021a\)](#). The wholesale approach of multi-CBDC may be built upon one of “three models: (i) enhanced compatibility; (ii) interlinking CBDC systems; and (iii) integration into a single system” ([Auer et al, 2021a](#)). The first may require some privately offered services (e.g. FX market?). The second involves a respective clearing system in the middle, while the third means sharing a CBDC infrastructure altogether. In case of a wholesale CBDC this may mean foreign banks having access to a domestic central bank accounts. This may be possible, but, in case of a retail CBDC, foreign citizens having access to a domestic CBDC may raise complex legal issues⁵¹. So there could be a need for an intermediary. [WEF \(2020\)](#) argues that wholesale CBDCs could bypass correspondent banking systems that are so costly and inconvenient for customers today. But they still note that existing frictions can also be addressed in other ways as well (e.g. extending operating hours or establishing clear data messaging standards).

Interoperable CBDC systems have so far sounded complex, but as time passes and we accumulate experience with several CBDC pilot projects, it is evident that achieving big changes on the cross-border payment front is possible. “Although many of today’s CBDC projects and pilots have a primarily domestic focus ([Auer et al \(2020\)](#)), various bilateral experiments have demonstrated the feasibility of using CBDCs for cross-border payments... At a basic technical level, this can involve reducing the barriers to membership of both systems, eg through common messaging standards and overlapping operating times. Moving beyond this, coordination between the systems can extend to common business arrangements, eg a designated settlement agent between the systems for certain payments”. ([Group of Central Banks, 2020](#)). As emphasized by [Auer et al \(2021a\)](#), there are already several projects directly aimed at facilitating cross-border payments like mCBDC Bridge, Project Dunbar, Project Jura, Project Stella or Project Aber. For a related discussion see also [DNB \(2020\)](#), [Adrian and Marcini-Griffoli \(2020\)](#), [Lannquist \(2019\)](#), [BIS \(2021a\)](#) or [Group of Central Banks \(2021a\)](#).

May require specific design choices:

Single mCBDC approach (the one with the highest harmonization across jurisdictions) requires a cooperation on digital ID schemes. Yet, “even in this model, with a single, jointly operated mCBDC system, a single ID system would not be needed; it would be sufficient for participating jurisdictions to recognise one another’s IDs. Making the most out of CBDCs in cross-currency transactions thus requires international cooperation” ([BIS, 2021a](#)). Also, an usage of a DLT with different jurisdictions could be useful, as in the project mCBDC Bridge,

⁵¹ Though same can be an issue in case of tourist usage.

since “deploying a scaled-up system based on this technology rather than a centralised ledger may have economic potential only wherever it is difficult for the involved jurisdictions to agree on a common governance arrangement” ([Auer et al, 2021a](#)).

Needed design choices may exclude other benefits or involve risks:

There are some reasons why achieving interoperability of CBDCs in different countries may be difficult: (1) differences in (AML/CFT) laws and regulations across countries as well as time zones, (2) differences in technology (e.g. blockchain standards) and (3) exchange rate risks (use of some major currency CBDC may undermine domestic monetary sovereignty). While the first two are more of technical issues, the latter is more of a policy issue. Technical ones may need some time but, eventually, it’s possible for many central banks to settle at some standard (“best practice”). The policy issue (monetary sovereignty) would need to be managed through other channels to make sure we reap the benefits of easier cross-border payments without creating bigger risks (like dollarization). This possibly could be the reason why some 43% of respondent central banks, survey by [OMFIF-IBM \(2019\)](#), said they were looking mostly at the domestic use cases. Things have changed somewhat, however, since 2019 (e.g. see projects listed above).

3.3.6. Supporting innovation

A well-established CBDC can, in this digital world, be a precondition for more innovation done by the private sector. As [BIS \(2020a\)](#) puts it “[t]he private sector can provide the innovation, ingenuity and creativity to serve customers better, but history illustrates that private sector services thrive on a solid central bank foundation. Whether promoting interoperability, setting standards or levelling the competitive playing field, there are strong arguments for the public sector to play a role. In fact, today the central banks’ role is as important as ever, if not more so.” And the role central banks can play in this journey seems to be in some form of a CBDC. Central banks could be operators (of public infrastructures, setting standards), catalysts (promoting interoperability) and overseers (ensuring level playing field and incentives for innovation).

Promoting interoperability in some sense naturally involves setting standards like “messaging and data (ie how a payment message and the data it includes would be formatted and structured), security (ie the cyber and endpoint security requirements) and others (eg operational processing and opening hour requirements or supervisory obligations)” ([Group of Central Banks, 2021a](#)). As for the competition side, when the new payment systems are introduced, existing legacy solutions feel more pressure to evolve and innovate. As the Chief Executive of SWIFT said in 2017, when he was introducing a global payments initiative (one-day settlement), they “could [not] have done this without the competition making it clear to the banks that they need to shape up their act”. CBDCs can do the same to competition and, hence, innovation. See also [Adrian and Marcini-Griffoli \(2020\)](#) or [CPMI \(2015\)](#).

Another side of innovation in payment systems is “programmability” of (digital) money ([BIS, 2020a](#)). This can help enhance economic welfare by enabling transactions that would have never taken place otherwise⁵². This benefit may be becoming more and more important, once

⁵² For example, automatic routing of tax payments or payments for Internet-of-Things.

more and more assets become tokenized ([DNB, 2020](#)). In turn, [Usher et al \(2021\)](#) sees possibility of introducing smart contracts as one of key benefits of a CBDC. For example, “smart contracts could enable automatic routing of tax payments to authorities at the point of sale, pay-as-you-go insurance or payments that can support [Internet of Things] applications”, which can reduce costs and enhance efficiency (relative to these tasks being done manually). These authors argue that, without a CBDC, competition in the payments system may get hit because of market power, threatening the pace of innovation. Also, coordination failure may make it optimal for central banks to issue a CBDC that will set standards and avoid an inability of the market to settle on a single new technological standard.

May require specific design choices:

Just like competition, promoting innovation may require a central bank operated CBDC infrastructure ([BIS, 2020a](#)), at least the basic one. Different market players having a connection through back-end interfaces or APIs, could build their services upon this shared infrastructure (ensuring a level playing field). In case of programmability of money, one may think that the prerequisite is a CBDC based on a DLT infrastructure, however this particular design choice may not always be necessary for making CBDCs a programmable money ([DNB, 2020](#)).

Needed design choices may exclude other benefits or involve risks:

Innovative solutions like smart contracts are prone to cyber risks. First, there can be logical errors in the contract code that can be exploited by hackers. Second, oracle risk is another attack vector – smart contracts that base an execution decision on outside inputs can be attacked. In addition, as emphasized by [Yifei \(2020\)](#), combining a CBDC with smart contracts, may make it lose its legal tender status. It could also reduce money velocity and complicate monetary transmission mechanism. Also, smart contracts could also compromise privacy. Finally, a “high demand for smart contracts can thus result in congested networks” ([Usher et al, 2021](#)).

3.3.7. Countering illicit activities

Partly as also discussed above, public infrastructure promotion in the context of a CBDC may help on many fronts, including digital ID systems that can help facilitate compliance with AML/CFT rules ([BIS, 2020a](#)). While [CPMI-MC \(2018\)](#) underscores the same potential benefit of a CBDC, it also cautions that it might be minor. The reason is that if a CBDC is designed in a way that tracks transactions then it “would not necessarily be the main conduit for illicit transactions and informal economic activities” – i.e. wouldn’t be as widely adopted, of course as long as other anonymous payment options (like cash) are still available. However, if the usage of cash decline as a result of a CBDC introduction, the benefit of minimizing illicit activities may still be non-negligible. For a related discussion see [Lannquist \(2019\)](#) or [WEF \(2020\)](#).

May require specific design choices:

“A centralised ledger would require an intermediary to manage and transfer the liabilities, making anti-fraud and security features easier to incorporate” ([Group of Central Banks, 2020](#)).

As per [BIS \(2021a\)](#), account-based approach is more compatible with the aim of countering illicit activity. Also, for a CBDC to (partly) substitute (illicit activity-prone) cash, it should have similar features – retail, instant. Obviously, it can't be fully offline (as it would be incompatible with the aim of fighting illicit activities), but, depending on a technology, it can probably be (third-party) privacy-preserving.

Needed design choices may exclude other benefits or involve risks:

Account-based access excludes the possibility of having full anonymity, even though “personal transaction data could be shielded from commercial parties and even from public authorities by appropriately designing the payment authentication process” ([BIS, 2021a](#)).

3.3.8. Consumer protection

Consumer protection in the form of protection from theft different from cash may be another objective of a CBDC ([DNB, 2020](#)). Private digital currencies may not automatically satisfy the key principles of consumer protection ([CPMI, 2015](#)), as this may be a topic involving some externalities (e.g. private benefit of misusing consumer data VS public benefit/cost). A CBDC can fill this void. In addition, as argued by [Lannquist \(2019\)](#) banks may be forced (by a competing CBDC) to offer better services to customers to remain competitive⁵³. In addition, a CBDC may improve consumer protection in terms of privacy. According to [BIS \(2021a\)](#), “[w]hen US consumers were asked in a representative survey whom they trust with safeguarding their personal data, the respondents reported that they trust big techs the least”, with traditional financial intermediaries having the most trust. Hence, introducing a CBDC (with the involvement of traditional intermediaries at consumer-facing stage) could be helpful in terms of providing consumers with data privacy right, if digital currencies from BigTechs (e.g. similar to Diem⁵⁴, formerly known as Libra) become prominent.

A somewhat related benefit of a privacy-preserving CBDC is that consumers may be able to monetize their payment data. For example, [Garratt and Lee \(2020\)](#) show that if there's no such CBDC, private digital payment methods may be used by firms in such a way that incentivizes consumers to use digital payment methods, but not be adequately compensated for that (i.e. consumer surplus being very small). Even if preventing such a behaviour from those firms was enforceable, if we were to prevent it, we would just stop the process of extracting benefits out of data altogether – so that now neither firms nor consumers would have much of a surplus. That's suboptimal. Instead, if we were to create a privacy-reserving CBDC that would compete with private digital payment methods (that use payment data), then the firms would be forced to transfer some of the surplus (generated from data usage) to consumers – i.e. consumers monetizing their privacy.

May require specific design choices:

Some form of an offline functionality of a retail CBDC (that periodically connects to an online system) may help consumer protection in terms of theft and loss. It may sound

⁵³ This, however, also has an implication for bank profits and, hence, possibly financial stability.

⁵⁴ Diem project has been stopped, but we may of course expect new Diem-look-alike initiatives from other parties.

counterintuitive at first, since (an offline) cash is particularly prone to theft and loss. However, a (otherwise online) CBDC that provides a temporary offline functionality with expiry dates has the potential to minimize such problems for consumers⁵⁵. The reasoning is the following: “inconvenience of a bearer instrument such as cash is that it is easily lost, with little possibility of recovery by the owner... This is different for a digital currency that is allowed to expire over time. Since money balances that remain unspent after their expiry date cannot be spent in the future, it would be safe for the central bank to reimburse the (most likely) owner in terms of online balances. The reimbursement of expired funds could be implemented in a fully automatic fashion without the need for the owner to file a loss claim. To further simplify end-user experience, the expiry date could automatically be refreshed before the funds expire whenever users’ devices connect to the network or are used to pay at a point-of-sale terminal with a network connection” ([Kahn et al, 2021](#)). Indeed, if money is lost, reimbursing it after being unspent is natural. If it is stolen, a thief will not have an incentive to go online (in a formal sector) with such stolen money. However, if s/he does not, then money will be reimbursed to the owner (who first converted an online balance into an offline balance).

Needed design choices may exclude other benefits or involve risks:

The key risk is that of cyberattacks, since the supposed benefit in terms of consumer protection comes from applying new technologies (e.g. partial offline functionality with expiry dates?) that have yet to be robustly tested.

4. Arguments against: potential risks / costs

As emphasized in the introduction, a CBDC project would not be (so far) the most “complicated project” ([Skingsley, 2016](#)) some central banks have initiated, unless it involved so many trade-offs between benefits and costs / risks. As we have already covered the former in the previous section, we will be digging deeper on the latter. There are lots of risks or costs possibly associated with a CBDC introduction, depending on design choices. While most of those have so far concentrated on the financial stability and payment system’s fronts, there are risks in terms of monetary policy and operations as well. This is what we discuss first.

4.1. Monetary policy and operations

It seems that a CBDC introduction may affect monetary policy and operations in a number of negative ways. However, those effects have rarely been studied in depth so far. Hence, our review of this particular part will also be relatively short. What has been mentioned in existing papers is the potential of a CBDC to make things worse in terms of a lower bound on interest rates, to threaten monetary policy independence by increasing incentives for governments to interfere with central banks or to potentially increase exchange rate volatility due to faster capital flows in and out of an open country.

⁵⁵ However, this may raise legal questions or questions on whether money with an expiry date is really money.

4.1.1. Exacerbating effective lower bound problem

As argued by [OMFIF-IBM \(2019\)](#), if a CBDC would be non-interest bearing, this would set a lower bound for central banks policy rates on zero much more firmly, excluding countries from pursuing negative interest rate policies, like Switzerland (which, at the time of writing this, had a policy rate of minus 0.75). In that case, if central banks would reduce policy rates even slightly below zero, everybody would easily rush to CBDCs (under the assumption that there's no quantitative restriction on CBDC holdings) – meaning somewhat reduced room for monetary policy maneuver. In addition, if CBDCs entail some financial disintermediation, then central banks will have to further ease monetary policy to offset the effect on the economy, further complicating the task of dealing with the effective lower bound problem.

This could also be negative news for the effectiveness of quantitative easing (QE) programs. QEs work through affecting term premium and, hence, longer-term yields. But, if short-term interest rates are at zero and going subzero is ruled out, then no amount of QE can lower long-term yields below zero. On the other hand, if short-term rates are at zero, but going subzero is *not* ruled out⁵⁶, then QE has the ability to get long-term yields even below short rate. The reason is that the ability of short rate to go below a certain point (in the future) determines whether holding a long-term debt *can* dominate rolling over short-term debt or not (see [Gagnon and Collins, 2019](#)).

Mitigation may require specific design choices:

To make sure zero percent is not a hard floor for interest rates, a CBDC should be able to pay negative interest rate, if needed. Hence, remuneration feature should be part of it. Whether this remuneration is generous (close to market rate) or not, is of second order importance specifically for this lower bound problem.

Mitigation may exclude benefits or involve risks:

A mere existence of a remuneration feature (without taking a stance on whether it is generously remunerated or not) does not seem to create other major risks or exclude benefits. In other words, making a CBDC remuneration time-varying, on its own, should not be particularly problematic in terms of other considerations. One exception could be anonymity. For interest to be paid on a CBDC or interest tax be deducted, the legal holder would probably need to be known, making it incompatible with an anonymity feature. Yet, smart contracts could be a possible future solution to this issue ([OMFIF-IBM, 2019](#)).

4.1.2. Reducing monetary policy independence

A possible threat to monetary policy independence as a result of a CBDC introduction is something that is not very widely discussed so far, possibly because of it being less likely in well-developed democratic societies. Still, theoretically this is relevant as CBDCs may, under some design choices, give central banks an ability to distribute money balances to the

⁵⁶ Which, at the very least, requires a presence of significant cash storage costs.

general public. As noted by [Group of Central Banks \(2020\)](#), “if fiscal transfers were made with CBDC there is a risk of blurring the division between monetary and fiscal policy and a potential reduction in monetary policy independence”. Of course, if these transfers are always financed by a reduction in other parts of the budget spending or increases in tax revenues or issuances of public debt in the market, this should not be problematic. What could be a problem is the distribution of helicopter money using newly created CBDC (i.e. CBDC making it easier to do monetary financing).

Mitigation may require specific design choices:

What can be seen on the surface is that, making sure fiscal transfers are done without any decision from central banks should minimize the threat to monetary policy independence. In other words, if a government wishes to transfer money to the people, it should do so through the private sector – for example, (i) transferring reserve balances (that it can obtain by issuing government bonds) to private banks in the name of recipients’ (e.g. households’) deposits, which (ii) private banks can transfer in those recipients’ CBDC wallets (exchanging reserve balances into CBDCs). This is much like cash, which is distributed by private banks even when it is created by central banks.

Mitigation may exclude benefits or involve risks:

An intermediated approach to a CBDC may most likely mean the need for people to have bank accounts, which would be linked to their CBDC wallets. This may exclude the benefit of financial inclusion in places where people lack access to bank accounts and where a mere existence of a CBDC is not a sufficient competitive push for banks to reduce fees for deposit account holders⁵⁷. Also, making helicopter drops easier may not be possible to achieve, if a clear division between monetary and fiscal policies is maintained (as is usually now today).

4.1.3. Increasing exchange rate volatility

Another less studied CBDC effect is that on exchange rate volatility. As argued by [Ferrari et al \(2020\)](#), if CBDCs would be available to foreigners (e.g. non-resident investors), it may increase volatility of exchange rate as it would be easier to rebalance international CBDC holdings. In other words, more volatility in capital flows may manifest itself in more volatility in exchange rates. Of course, if CBDCs are just used by tourists, this may not have an outsized impact on the exchange rate. What could matter in terms of exchange rate volatility is if central banks allow a CBDC to become a store of wealth for foreign investors.

Mitigation may require specific design choices:

If CBDCs will not be facilitating cross-border payments, increasing the exchange rate volatility may not be a separate concern. However, improving cross-border payments is one of the key motivations for (wholesale) CBDCs. Hence, central banks may not refuse more efficient cross-border payments. On the domestic front, if CBDC holdings are capped, then

⁵⁷ Which also explains why the optimal CBDC model is country-specific.

capital flow volatility may increase only slightly, which would limit extra exchange rate volatility.

Mitigation may exclude benefits or involve risks:

Imposing caps on CBDC holdings (quantitative restrictions) makes it difficult to fight currency substitution or improve the monetary transmission mechanism, which require a remunerated CBDC without binding quantitative caps. Quantitative limits on CBDC holdings may also exclude the possibility of doing helicopter drops easier than it's possible today (e.g. using cheques) – those who have a CBDC account but not a bank deposit account may not be technically able to receive money without hitting the ceiling.

4.2. Financial stability

Just like for payment systems, money creation has now long been operating within a two-tier system: one part is private financial intermediaries (e.g. commercial banks or cooperative banks) and the other is a central bank. It's not only central banks that "print" money⁵⁸. It's both parties that are in the business of money creation⁵⁹ (see [McLeay et al, 2014](#) or [Jakab and Kumhof, 2019](#) for a survey on both theory and evidence). See also [Goodhart \(2017\)](#). When there's demand from non-financial sector⁶⁰, private intermediaries create private money (mostly in the form of current account deposits nowadays), while central banks create public money (in the form of physical cash and reserves⁶¹). One of the key aspects of CBDCs is whether they displace the former or the latter. If a widely adopted CBDC competes with private money, instead of existing public money, then the implications for financial stability can be huge. This is the scenario discussed in this subsection.

4.2.1. Financial disintermediation

Several papers have raised concerns that an introduction of a CBDC that may compete with private bank deposits could lead to reducing banks deposit base or forcing them to increase interest rates, potentially hurting credit extension (e.g. see [Adrian and Marcini-Griffoli, 2020](#) or [BIS, 2020a](#)). More specifically, banks may have to resort to wholesale funding which usually is more expensive and volatile and could generate tighter conditions for new loans. Also, it could become more difficult for them to meet the Net Stable Funding Ratio (NSFR) requirement when savings deposits are replaced by wholesale funding. For a related

⁵⁸ Actually, central banks are quantitatively much smaller players in this sense ([McLeay et al, 2014](#)).

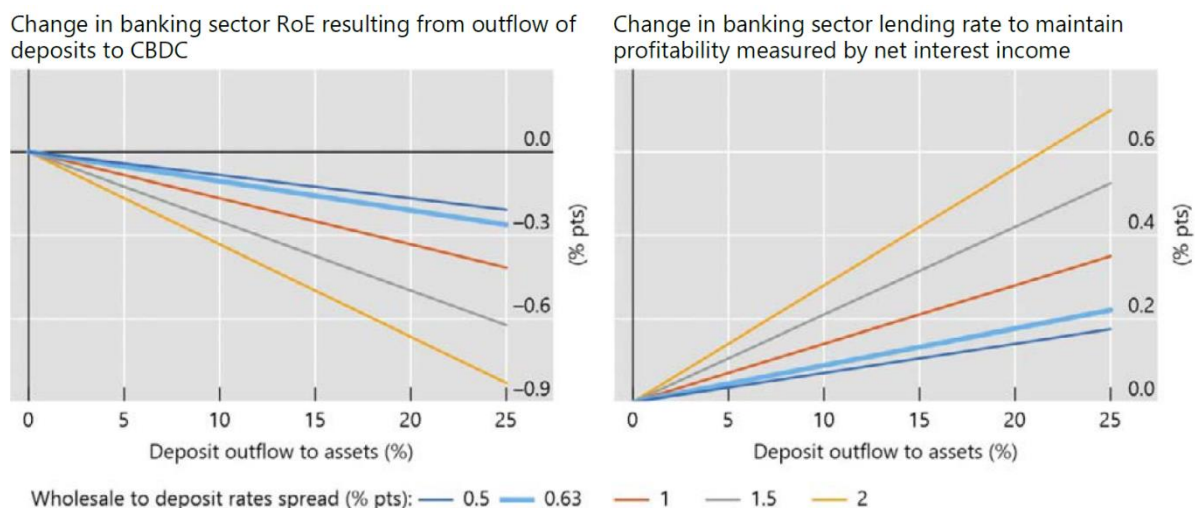
⁵⁹ Hence, central banks collect seigniorage income from only one part of the overall money stock. Income from creating private forms of money (e.g. current account deposits), done by depository institutions, accrues to those depository institutions. The origin of the banks' income is on the asset side of their balance sheet, viz. interest they earn on their loan portfolio, funded by issuing liabilities that pay lower interest. Moreover, as they create their own funding in the process, this also brings an advantage, especially in a high-interest rate environment.

⁶⁰ In other words, banks can create money only when there's a demand for loans or people that want to sell illiquid assets to their bank.

⁶¹ But reserves are a form of a central bank money that only financial intermediaries can use at present.

discussion see also [Lannquist \(2019\)](#), [CPMI \(2015\)](#), [CPMI-MC \(2018\)](#) or [WEF \(2020\)](#). In terms of quantifying these effects, [Group of Central Banks \(2021c\)](#) estimates how big an impact this would have on Return on Equity (RoE) and, hence, by how much should lending rates increase to maintain an existing level of profitability. As the simple calculations show, quite intuitively, the higher the spread between wholesale funding cost and bank deposit rates the higher is the effect on lending rates (see Figure 5). Hence, they conclude that for those financial systems where a CBDC introduction pushes interest rates up, financial disintermediation may follow because of less demand for credit.

Figure 5 – Possible effects of a CBDC introduction on lending rates



¹ See Annex A for details on data sources and model parameters.

Source: Country Banking Data Tables from CGFS publication No. 60, BIS bank level asset data and BIS bank level deposit and CDS rates. Data is obtained for a subset of advanced economies.

Source: [Group of Central Banks \(2021c\)](#)

The figure also implies that the disintermediation effect of a CBDC would be more modest in low interest rate environments, because deposit rates in there are already close to wholesale funding rates (today, both are close to zero). One Swedish Riksbank publication, for example, has also estimated that the adoption of an e-krona could raise the cost of bank funding by only up to 25 basis points ([Juks, 2018](#)). Still, even this is already non-negligible and the effect could be much more dramatic in emerging markets where there's a substantial difference between deposit rates and wholesale funding rates. [CPMI-MC \(2018\)](#) also notes that possible disintermediation and shrinkage of banks' profit margins may force banks to take on riskier positions and, hence, increase systemic risks through this additional channel.

However, as argued by several authors, bank disintermediation may not necessarily be the result of a CBDC introduction. For instance, [Brunnermeier and Niepelt \(2019\)](#) argue that banks can be supplied liquidity from central banks avoiding the bank disintermediation and the only difference being the difference between the central bank lending rate and deposit funding rate. Namely, if central banks provide liquidity at the same rate that banks fund themselves with deposits, there's no change for a bank – whether it funds itself with deposits or with wholesale funding, doesn't change the picture. As also mentioned above, they argue that this conclusion is mostly true after the global financial crisis, because interest rates on central bank lending rates and deposit rates are similar since then (both are, in many cases,

close to zero). Central bank's providing the necessary liquidity is what they call a pass-through funding – central banks taking the place on private banks balance sheet which were previously taken by retail deposits (as households switch from deposits to CBDCs). See also [Niepelt \(2021\)](#). Indeed, around half of the panel members surveyed by [Crumpton and Ilzetzki \(2021\)](#) for the case of UK think that introducing a CBDC would have no or little effect on the banking sector, while the other half is split on whether the effect would be positive or negative. Hence, it looks like economists are still yet to decide if banking sector disintermediation risks are big enough to outweigh other benefits.

Mitigation may require specific design choices:

“Moderating CBDC take-up would be the most direct route to mitigate the identified risks from the potential substitution of CBDC for bank deposits and relatively low risk assets including money market funds. Authorities could implement two broad categories of safeguards that moderate CBDC take-up and usage: (i) quantity-based safeguards; (ii) price-based safeguards” ([Group of Central Banks, 2021c](#)). A quantity-based approach would involve some hard limits on CBDC holdings (stocks) or transaction volumes (flows), while price-based approach is essentially a (possibly tiered) remuneration policy.

Non-generous remuneration is one of the key prescribed features here ([Auer et al, 2021b](#)). To mitigate this potential risk, [BIS \(2020a\)](#) also argues in favor of remunerating CBDCs at a lower than the policy rate or limiting the amount of CBDCs in the hands of the public (caps). As [DNB \(2020\)](#) points out, it is also a good idea to introduce CBDCs gradually to see how consumers react to differences between deposits and CBDCs, so that the disintermediation argument can be quantified better within some control group (that would have access to CBDCs). See also [Group of Central Banks \(2020\)](#). On the other hand, according to [Bordo \(2021\)](#), supervision (that boosts confidence), (retail) deposit insurance and lender of last resort functions can “effectively head off disintermediation” risk, without much need for other mitigating features.⁶²

Mitigation may exclude benefits or involve risks:

Two key features are below-market rate (or no) remuneration and/or quantitative limits on CBDC holdings/transactions. These design features contradict, foremost, with the aim of fighting currency substitution. Also, CBDCs giving central banks a possibility of helicopter drops may not always be feasible with quantitative limits, unless done with an overflow approach (i.e. CBDC being linked to a bank deposit account). In other words, this may potentially make it impossible for people with a CBDC account but not a bank deposit account to receive money without hitting the ceiling, if they are already close to the limit. Quantitative caps may also create problems in terms of the one-to-one convertibility (fungibility) promise, if a CBDC is to (fully) replace cash.

⁶² However, the issue here is that a CBDC is a new thing and we can't really know ex-ante if a bank run will happen. One can imagine a CBDC that is perfectly harmless in normal times, but that facilitates a bank run in times of crisis.

4.2.2. Bank runs

One of the scariest possible risks that have been mentioned around CBDCs is its potential to spur digital bank runs (e.g. see [BIS, 2020a](#)). [OMFIF-IBM \(2019\)](#) survey shows that central banks fear increased risk of digital bank runs the most. According to that report, “without any frictions in the transfer of funds from customer accounts at commercial banks to central bank accounts could result in bank runs being more sudden and larger”. As a result, central bank balance sheets could become much more volatile (and bigger). [Monnet et al \(2021\)](#) empirically confirms the suspicion that the presence of safer public deposits facilitates bank runs from private deposits during stress periods. They provide the empirical evidence based on data on activity during the French Great Depression (1930-1931), when deposits from unregulated banks flew significantly to savings institutions guaranteed by the government. See also [DNB \(2020\)](#), [CPMI-MC \(2018\)](#), [WEF \(2020\)](#) or [Group of Central Banks \(2020\)](#).

However, according to [Adrian and Marcini-Griffoli \(2020\)](#), in many (emerging and developing) countries runs happen from domestic currency, not (just) from deposits. Hence, in those cases, whether there’s a CBDC or not, the problem of run is still roughly the same.⁶³ Therefore, authorities should be concerned with this risk with or without CBDCs. Building credible monetary policy frameworks and track record of domestic stability may be key.

Mitigation may require specific design choices:

One possible remedy is central banks providing as much liquidity as needed – pass-through funding ([Brunnermeier and Niepelt, 2019](#)). Another solution to this problem could be smart contracts that can slow down a digital run by making it difficult to convert deposits into CBDCs ([OMFIF-IBM, 2019](#)). Imposing hard quantitative limits on holding CBDCs is also on the table ([Group of Central Banks, 2020](#)). Setting a time-varying spread between deposit rates and CBDC rates is also an option – lowering them when demand for CBDC is low and increasing them when it is high (e.g. during bank runs). However, [CPMI-MC \(2018\)](#) argues that simply changing the price (interest) of CBDC is insufficient to stem off such digital runs in times of stress “when agents seek safety at almost any price”. Hence, quantitative limits may be unavoidable in such scenarios, if unlimited liquidity injections aren’t possible. [Monnet et al \(2021\)](#) also conclude that hard ceilings on those type of safer deposits (like CBDCs) would seem the most effective way to stem off runs. However, they also acknowledge that if those inflows to safer deposits were passed on to the banking system, the run may not had been so severe. Hence, in today’s context, liquidity injections by central banks could indeed be a remedy. [Bordo \(2021\)](#) argues that the possibility (brought by CBDCs) to set negative policy rates would essentially “ensure that private credit rates remain at moderate positive levels, thereby preventing a huge wave of defaults and bankruptcies and fostering the stability of the real economy, which in turn boosts confidence in commercial banks and mitigates the risk of a run.”

Mitigation may exclude benefits or involve risks:

A possible problem with (permanent) quantitative caps is that the parity may break down – leading to imperfect substitutability between different forms of (in principle, same) money,

⁶³ However, one should still take it into account that digital flows take less time and can be more abrupt.

especially when limits of CBDC usage are hard limits. In other words, quantitative limits imply an (implicit) exchange rate between cash and a CBDC, which is in conflict with one of key foundational principles or core features [Group of Central Banks \(2020\)](#) sets out: “a CBDC should maintain and reinforce the ‘singleness’ or uniformity of a currency, allowing the public to use different forms of money interchangeably”. Alas, that same paper discusses the way of imposing quantitative limits. In addition to the fungibility issue, if limits are too strong (to deter bank runs) it may also reduce the appeal of CBDCs (leading to very weak adoption). All these may make it impossible to achieve the aim of fighting currency substitution with a CBDC. Also, as before, caps could become inconsistent with the possibility of helicopter drops, if needed⁶⁴.

On the other hand, if unlimited supply of liquidity is the way chosen by central banks (instead of imposing quantitative limits), then an issue of collateral sufficiency pops-up. If collateral base is expanded this may solve the problem. But if there are no more risk-free assets to be included in central banks’ collateral bases, they may be forced to include risky assets (e.g. banks’ loan asset portfolios) into their collateral bases. Obviously, haircuts will be such that central banks will think they’re protected from risks. The problem, though, is that this essentially means central banks becoming involved in credit allocation (see below).

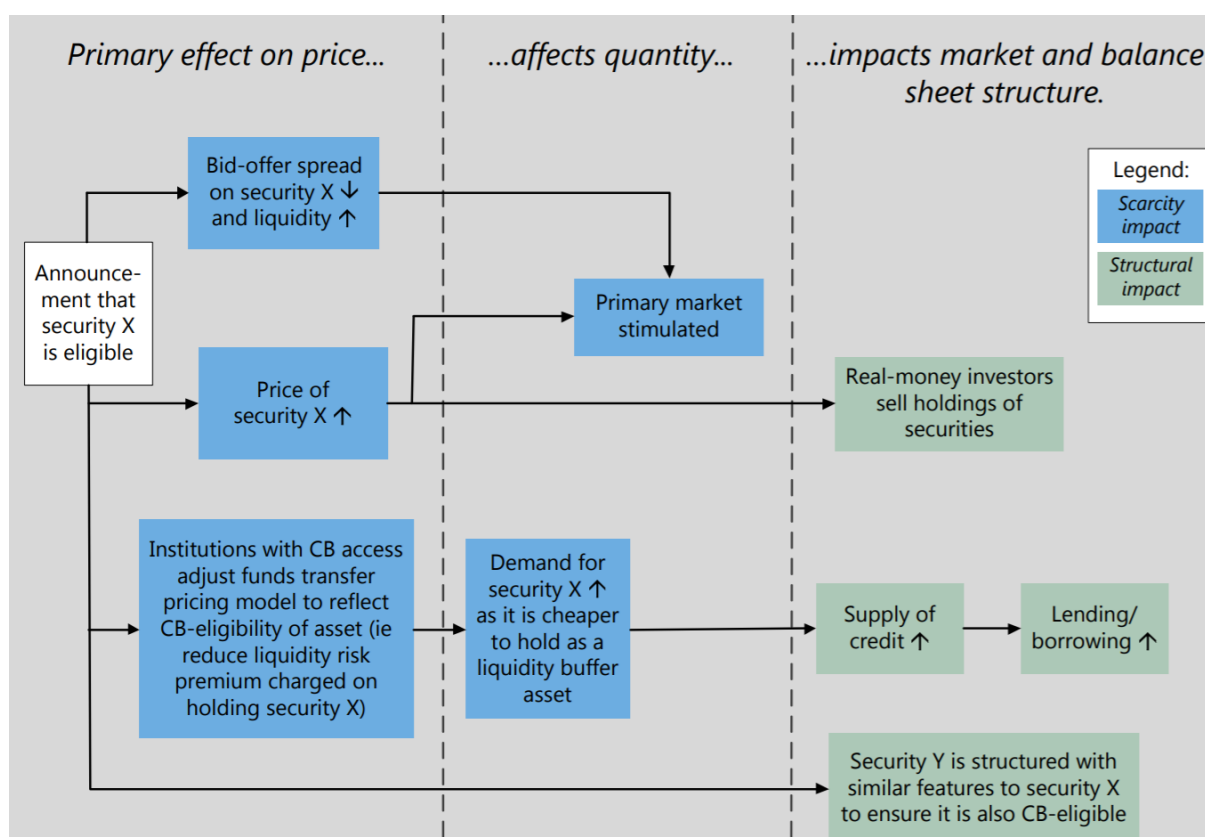
4.2.3. Larger state footprint in credit allocation

As emphasized by [DNB \(2020\)](#), if a CBDC will become widespread so that people exchange their commercial bank deposits for CBDCs, then the central bank will have to accommodate this increased demand for public money by expanding its balance sheet (which will let reserve money explode), or otherwise interest rates will increase. This means central banks holding more assets. The issue is when traditional assets, like government securities, become less available, central banks will have to decide on which assets to purchase – hence an increased role of central banks in financial intermediation⁶⁵ (see Figure 6).

⁶⁴ A potential remedy here could be a flexible cap, which can be raised when a government decides to distribute helicopter money. But this will be hard to do if people decide to massively transfer their money to their CBDC accounts.

⁶⁵ To some extent, this is already happening (through some large-scale asset purchases done by central banks), but an introduction of a CBDC could make the issue much more acute, especially in countries where near risk-free assets are relatively scarce.

Figure 6 – Possible impacts of making a new asset central bank-eligible



Source: [BIS \(2015\)](#)

[CPMI-MC \(2018\)](#) also states that “if flows into CBDC were to become large and not associated with offsetting declines in physical banknotes, as could be the case in times of financial stress, challenges could arise (such as a need to broaden the assets that the central bank can hold or take on as collateral)”. Buying an asset or not buying it at the expense of another asset means an involvement in credit allocation. Lending to commercial banks against risky assets as collateral is a similar distortion of market forces (of allocation), since a central bank “does not take into account the bank’s risk profile in this type of funding”, with all banks having access to the same facility ([DNB, 2020](#)). See also [BIS \(2020a\)](#). Indeed, as emphasized by [BIS \(2015\)](#), several transmission channels can make taking risky assets as collateral (even with high haircuts) being similar to credit allocation. The same paper reports that financial market participants also think that collateral acceptance (of a given asset) is very important for the market (of this particular asset). Then, if this issue becomes too big, less use of decentralized information acquisition could mean less effective allocation of resources, which could result in a build-up of more financial risks.

Mitigation may require specific design choices:

To avoid an issue of being forced to expand a collateral base so much that it clearly becomes credit allocation, quantitative limits on CBDCs may be needed. Most likely those limits should be on stocks (holdings of CBDCs), rather than flows (transactions).

Mitigation may exclude benefits or involve risks:

As mentioned above several times, imposing quantitative limits on CBDC holdings may cause issues with fungibility of money, inability to fight currency substitution or inability to make (as of yet, theoretical) helicopter drops only at the discretion of central banks⁶⁶.

4.2.4. Systemic risk of payment systems

In case a CBDC becomes the major payment method, then the infrastructure would be too important to fail for central banks and too important not to try hacking for hackers. In case the system experiences even a temporary setback, it can absolutely precipitate credit crunch and liquidity crisis ([BIS, 2020a](#)). Clearly, this risk is not specific for CBDCs – we face this risk now as well. The only aim of this subsection is to highlight that CBDCs will probably suffer from the same problem of payment systems having a systemic risk in it.

Mitigation may require specific design choices:

One potential remedy is using a decentralized system, which is more resilient to attacks (see the section on design principles). Also, as emphasized above, usage of programmability can be a source of risks. Hence, central banks may wish to implement some form of only basic infrastructure. In this vein, an indirect approach also seems less likely to suffer from the systemic risk issue.

Mitigation may exclude benefits or involve risks:

Convenience may be less, if a decentralized system is unable to process large numbers of transaction in a short period of time. How to reverse a fraudulent transaction in a blockchain system is also an issue to be discussed. Of course, technological risks are also noteworthy. In addition, in a permissioned system, there could be an issue of moral hazard ([Auer et al, 2021b](#)).

4.2.5. Financial exclusion

While most work has focused on the positive impact of CBDCs on financial inclusion, [Lannquist \(2019\)](#) emphasizes the possibility of CBDCs actually being counterproductive in this sense – i.e. promoting financial exclusion, rather than inclusion. The channel of this happening could be part of the population not adopting CBDCs and, hence, becoming marginalized from digital payments, which will probably become a bigger part of the payments (and economy's) landscape especially if CBDCs are introduced. People that may have a bigger risk of being marginalized from digital economy are those with disabilities or elderly. For instance, a survey by [Vogels \(2019\)](#) from Pew Research Center shows that only 40% of older people in the US⁶⁷ own a smartphone (see Figure 7). See also [WEF \(2020\)](#).

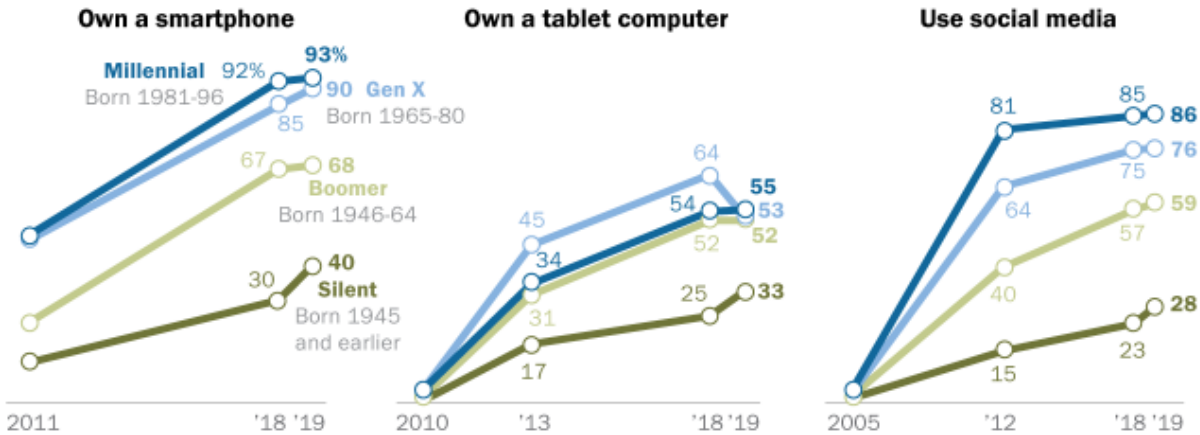
⁶⁶ Of course, if we have monetary and fiscal coordination, one can do helicopter drops in the current system as well, like it was done during the Covid-crisis by simultaneously easing monetary and fiscal policy.

⁶⁷ There will obviously be differences between countries, however general trend should be somewhat similar.

Indeed, as shown by [Auer et al \(2020b\)](#), based on simple regressions as well as multivariate ordered probit regressions, higher mobile and internet use is associated with higher propensity of authorities to be engaged in some CBDC work. More specifically, “a one standard deviation increase in mobile phone subscriptions is associated with a 55–63% higher probability of moving from no work to research, or from research to a pilot”. This is a reflection that the usage of technology being wide enough could be a necessary condition for a CBDC introduction. Otherwise, financial exclusion risks are real.

Figure 7 – Elderly people at more risk of financial exclusion

% of U.S. adults in each generation who say they ...



Note: Those who did not give an answer are not shown.

Source: Pew Research Center

Mitigation may require specific design choices:

As [Group of Central Banks \(2021a\)](#) notes “intermediaries naturally have an incentive to cater to users likely to generate the most profit. Therefore, an ecosystem in which the public could only access CBDC through private intermediaries might struggle to achieve universal access or services for all relevant use cases. To overcome this, a central bank or other public body (eg a post office or government bank) could offer services, legislation requiring basic access could be proposed and/or incentives for private intermediaries to supply otherwise underserved end users could be introduced”. Though, this may differ strongly between countries.

As for older people potentially struggling to use a CBDC technology, there doesn’t seem to be any specific CBDC technological feature that may directly deal with it. Instead, a CBDC should try to not fully displace cash so much that stores stop accepting it (as cash is easily used by older people). For example, an account-based CBDC may mean that demand for anonymous cash would still linger on. Hard limits on CBDC holdings could potentially also be used – younger people in low income groups may still find a CBDC useful for payments, but a quantitative limit (that wouldn’t be binding for them) may help maintain some demand for cash (which older people may be relying on).

Mitigation may exclude benefits or involve risks:

If free basic access is introduced, someone should bear costs of its operation (probably a fiscal agent). If a CBDC is designed not to fully replace cash (e.g. by being account-based), it may compete with deposits more, or simply take-up could be very low. If quantitative limits are enforced, this may be at odds with the aims of clearly maintaining fungibility of money, fighting currency substitution or making (as of yet, theoretical) helicopter drops.

4.3. Payment systems

In case a CBDC becomes widely adopted medium of exchange, this *can* totally change households and businesses' experience with payment systems. In this subsection we consider the implications in this case, in terms of potential additional costs and risks. This is an important question as, according to [Petralia et al \(2019\)](#), payments systems are the most disrupted ones from new technologies and this will inevitably create new risks down the road that will need to be carefully managed.

4.3.1. Technological risks

As one central bank puts it, CBDC systems will “have to meet the highest cybersecurity standards, as even minor cyber-incidents may pose severe reputational risks to central banks and undermine the public’s trust in the currency” ([OMFIF-IBM, 2019](#)). According to [OMFIF \(2020\)](#) 82% of surveyed central banks or regulators think that cybersecurity is the main concern. [WEF \(2020\)](#) also emphasizes the reputational risk coming from CBDC system potentially failing. In addition to the reputational side, [CPMI-MC \(2018\)](#) considers cybersecurity risk as “one of the most important operational challenges for central bank systems and the financial industry more generally”. [Aldasoro et al \(2020\)](#) emphasizes that too much cloud dependence creates a tail risk of cyber-attacks and digital currencies with large networks can be a similar source of vulnerability. [Lannquist \(2019\)](#) argues that the usage of blockchain technology may also be a source of technology risks in the form of issues with “transaction scalability, user experience, key management, confidentiality and transaction speeds”. [Wolfram \(2020\)](#) also mentions an issue related to a quantum computer resistant technology. See also [Group of Central Banks \(2020\)](#), [Adrian and Marcini-Griffoli \(2020\)](#) or [BIS \(2020a\)](#).

Mitigation may require specific design choices:

To minimize cyber-risks design should be either within a DLT approach or with multiple data centres. This makes sure that hacking a single databased doesn't result in a complete loss of control over transactions history. Refraining from programmable features may also simplify the system, so that securing a core system is easier.

Mitigation may exclude benefits or involve risks:

Usage of a DLT technology may be a double-edged sword. As also underlined above, DLT may provide resilience benefits relative to a centralized system, by maintaining a web of databases. However, new technologies in general also come with a tail risk of potential weak

points that hackers may find down the road. Also, “[w]hile in principle distributed ledger technology (DLT)-based systems may offer resilience benefits, by replicating data over many more computers, so could a centralised ledger with a small number of data centres.” ([Group of Central Banks, 2020](#)). Also, inconvenience could be an issue if an usage of a DLT would mean processing large numbers of transaction in a short period of time being infeasible.

4.3.2. Privacy concerns

[WEF \(2020\)](#) warns that while the possibility of tracking CBDC movement may make central banks or PSPs task easier, external parties being able to track people and stole personal data also becomes easier. That’s why the system should incorporate as much anonymity, or privacy more precisely, as possible (clearly, at least, minimally consistent with AML/CFT requirements). That report also notes the complexities related to, for instance, regulating foreign-country CBDCs as own citizens may become victims of data privacy abuses when using those foreign CBDCs. Smart contracts may potentially also compromise privacy. See also [Petralia et al \(2019\)](#), [BIS \(2019\)](#) or [Lannquist \(2019\)](#).

Mitigation may require specific design choices:

At the end of the spectrum is (almost) full anonymity (pseudonymity), similar to the Bitcoin system. Some authors also consider private payment service providers handling retail transactions, while a central bank being involve only at the wholesale level – “benefits of such an ‘intermediated’ CBDC architecture would be a diminished need for centralised data collection and perhaps better data security due to the decentralised nature of record-keeping” ([BIS, 2021a](#)).

Mitigation may exclude benefits or involve risks:

Full anonymity (as much as digitally possible) would be inconsistent with the aim of countering illicit activities. Consumer protection could also be an issue with anonymous digital payments ([Saunders, 2019](#)). In addition, anonymity may complicate paying interest on a CBDC (see also the previous section). Another downside to having a decentralised record-keeping at the private PSP level could be “that additional safeguards and prudential standards would be necessary, as PSPs would need to be supervised to ensure at all times that the wholesale holdings they communicate to the central bank accurately reflect the retail holdings of their clients” ([BIS, 2021a](#)).

4.3.3. Supporting illicit activities

[BIS \(2020a\)](#) highlights a risk of money laundering and illicit financing related to a CBDC that provides sufficient degree of anonymity. While this is an obvious risk, not much attention has been paid to it, possibly because the expectation is that no authority would allow such an anonymous CBDC which supports illicit activities. However, abstracting from that kind of an expectation, illicit usage is still a risk in general terms.

Mitigation may require specific design choices:

“[T]he more anonymous the instrument and the more decentralised the transfer mechanism was, the greater the opportunity for cross-border activity, arbitrage and concealed

transactions would be, with related reputational risks for the central bank” ([CPMI-MC, 2018](#)). Hence, even if third-party privacy is enforced, there should be a way for law enforcements to be able to track illegal usage of a CBDC.

Mitigation may exclude benefits or involve risks:

Providing sufficient degree of privacy may not be possible if tracking illegal activities is to be operational (easy). General inconvenience with the knowledge that a government is watching your transactions is the most obvious risk. However, a more important tail risk could potentially be abusing the ability to track transactions. Yet, this is mostly an issue in an autocratic society, discussing of which is beyond the scope of this paper.

4.3.4. Cost of operating CBDC infrastructure

Obviously, operating a CBDC infrastructure is costly. These costs will be especially large in a CBDC design where the central bank performs the KYC/AML/CFT functions directly ([CPMI-MC, 2018](#)). “Directly recovering costs from the public users would be transparent but could be a disincentive to adoption. Assigning a public good and/or seigniorage earned by the central bank could reduce or eliminate the need for charges. Charging service providers would require them to have a viable business model to recover their costs... Decisions will be required on whether all costs are transparently charged through fees (and whether these are borne by merchants, users or both) or if some subsidisation through public funding, private cross-subsidy or allowing access to consumer data is permitted” ([Group of Central Banks, 2020](#)). See also [Adrian and Marcini-Griffoli \(2020b\)](#).

Mitigation may require specific design choices:

An intermediated approach could lower costs for central banks, as private entities would be running AML/CFT checks. Yet private entities would be inclined to pass-through these costs to consumers (merchants, households). Hence, one option is setting fees that could help cover operational (and compliance) costs. The same can be achieved by seigniorage income – not remunerating a CBDC (or remunerating it at a rate considerably below the market rate).

Mitigation may exclude benefits or involve risks:

Private entities (PSPs) performing most CBDC functions (except the core of issuing them and alike), may mean there will be a need for supervision of PSPs to make sure incentives are aligned ([BIS, 2021a](#)). Setting fees may considerably lower CBDC adoption and hurt financial inclusion ([Group of Central Banks, 2020](#)). Relying on more seigniorage income (non-market rate remuneration) also means fighting currency substitution will be much more difficult.

4.3.5. Driving private payment systems out

As argued by [BIS \(2020a\)](#) payments systems work most efficiently and effectively under a two-tier system, where both public and private systems operate side-by-side. However, if CBDCs turn out to be a real competitor for private payment systems (e.g. debit and credit cards), then the resulting system will not be a two-tier one any more – endangering everything that comes with competition and private sector incentives (innovation, user experience). Hence, as CBDCs were described as a possible source of incentive to further innovation in

the previous section, it can be seen a double-edged sword. CBDCs would have to balance how strongly they compete – not too weakly (that fails to result in positive disruption and innovation) and not too strongly (that may drive private players out of the payments market). In other words, if CBDCs become too successful, they would also become “single points of failure” ([Cunliffe, 2020](#)). This risk can happen quickly or even unpredictably, because of network effects – the more people use a CBDC the more it is optimal for others to use the same payment system ([Katz and Shapiro, 1994](#) or [Claessens et al, 2003](#)). This is a positive network externality that can result in too much of something. What’s more, this risk is particularly true for digital currencies ([BIS, 2020a](#)). Hence, when networks externalities are present, for a new payment product to be able to compete it may need a “policy interventions such as aggressive marketing efforts or pricing below marginal cost” ([Gowrisankaran and Stavins, 2004](#)), which is improbable.

Mitigation may require specific design choices:

An intermediated/hybrid approach would be necessary to make sure there’s a need for private players in a CBDC architecture by design. For example, this could mean a central bank being the operator of the basic infrastructure, while private agents access it through APIs. This can indeed create level playing field, but it can still contain technological risks (cyber-attacks). As before, more resilience to cyber-attacks could be achieved by using a DLT-type approach or having several independent data centers with a copy of a ledger.

Mitigation may exclude benefits or involve risks:

Private players being involved in much of operations may mean more need for supervision, especially for new players, since banks are already being closely supervised. Also, decentralization aimed at resilience should not result in scalability issues with large number of payments. Otherwise, a CBDC would be inconvenient for payments. Again, possible cyber-attacks are also noteworthy.

5. Under-researched areas

CBDC literature is evolving very fast. Technologies change very fast, and so do policy implications, not only on the payment system side, but also on the monetary and financial stability sides. Yet this strand of the literature is also quite new in its current form, content and areas it tries to research. Hence, there naturally are parts of the topic that need more scrutiny. In this section, we discuss some key under-research areas, hoping that it will lay some ground for future work to shed more light on them.

5.1. Interlinkages (between benefits, costs and design choices)

One of the most important missing pieces in the CBDC literature is analyzing three-dimensional interlinkages between CBDC benefits, costs and design choices in a structured way. Many papers have underlined some of trade-offs that central banks may face, but this has not been done in a systematic manner, by incorporating *all* the trade-offs and their interlinkages in a unifying framework (even if static). For example, if one wants to fight currency substitution with a CBDC, its remuneration should be generous enough. However,

this then raises the question of financial disintermediation (in addition to other issues like being incompatible with a high degree of anonymity). The latter risk may be dealt with quantitative limits. However, those kind of caps may be against the aim of fighting currency substitution (i.e. trade-off). Then, if instead of caps, we try to head off disintermediation by unlimited supply of central bank liquidity, this, in turn, leads to concerns around collateral policy and too high state footprint in financial intermediation.

These are just a few examples from a very rich set of linkages between all three benefits, costs and design choices. Understanding these three-dimensional interlinkages is a necessary input for an optimal design of a CBDC based on priorities of each authority. Namely, it will help them identify the necessary design choices that strikes the right balance (for them) among all the benefits and all the costs of a CBDC.

5.2. Competition for money VS competition for credit

Another part of the literature that may contain some confusion is around a CBDC's impact on the cost of credit. The literature seems to not have identified a clear mechanism through which a CBDC can affect the degree of competition in the business of *extending credit*. Some papers have argued that, because CBDCs can increase the degree of competition for money (e.g. CBDC VS commercial bank deposits), they will necessarily squeeze banks profit margins. However, competition for money is a different thing than competition for extending credit. Put differently, it's one thing for households and businesses to realize that now they have more options in terms of how many forms their *existing* money can take (e.g. swapping deposits for newly introduced CBDC), but it's totally different thing whether now there are more options in terms of ways *new* money is created or not. Households and businesses can't create new money⁶⁸ on their own. They can only change the form their existing money takes. In contemporary systems it's only financial intermediaries that can create *new* money mostly through the act of lending⁶⁹ (obviously, lending implies that there should be someone who wants to borrow). That is, if the public wants to create new money, they should make sure they obtain a credit from financial intermediaries. And unless credit can now be extended by new additional players or at a lower cost (as a result of CBDC introduction), we can't really argue that the competition will on its own lead to more money creation.

This is important, since not acknowledging this difference may result in erroneous conclusions. For instance, if we believe that a CBDC will increase the degree of *competition for credit extension* between financial intermediaries (defined broadly, i.e. those that can extend credit and create new purchasing power or money), then this may make us think that a CBDC may actually increase lending. After all when there's more competition for a product, there should be more of it produced. That is, we may think a CBDC may actually *increase* intermediation not decrease. Indeed, this is the result that [Chiu et al \(2019\)](#) get. See also

⁶⁸ For instance, even if they decide to increase deposits (meant to increase the total money supply), they can only do so at the expense of a decrease in other forms of money, e.g. cash (hence, making sure the total money supply remains unchanged). Total money supply increases *only after* financial intermediaries *decide* (and borrowers have demand) to extend new credit. Note that here we consider the money supply in the hands of non-financial agents.

⁶⁹ Mostly, because they can also do this by buying other assets (other than loans, e.g. office buildings, etc.) or by shrinking their equity.

[Andolfatto \(2021\)](#), which gets the same result under liquidity-constrained banks. This line of argument stresses that because CBDC may compete with deposits, interest rates on deposits will increase and this will *cause* higher amount of deposits (because more consumers will want them). Based on this, they conclude that CBDCs may actually increase intermediation. But as we discussed, (under interest rate targeting frameworks pursued by most central banks) that conclusion is a result of a confusion between competition among the forms existing money can take and competition among intermediaries that can create new money⁷⁰.

Look at it differently: even if deposits do increase (because of higher deposit interest rates, as a result of CBDC introduction), this just happens at the expense of cash with the total money supply (in the hands of non-financial agents) being unchanged. One may argue that now banks will have more cash (liquidity) to “lend-out”. But this isn’t true in interest-rate-targeting frameworks. For more liquidity to be able to generate more lending, it should cause (at least temporarily) lower interest rates on money markets. However, today (at least during times when a liquidity crisis doesn’t seem imminent) its central banks *deliberate* decisions (e.g. through Monetary Policy Committee meetings) that can reduce interest rates on money markets. Otherwise, if additional liquidity doesn’t result in lower interest rates, new loan extensions aren’t likely to happen – meaning that new money creation won’t take place⁷¹. Hence, more research is needed whether an introduction of a CBDC helps more players become financial intermediaries or not. Or, as noted by [CPMI-MC \(2018\)](#) “[f]urther research on the possible effects on interest rates, the structure of intermediation, financial stability and financial supervision is warranted”. What’s at stake is whether CBDCs would generate financial disintermediation or not.

5.3. CBDC and collateral policy

The implications of CBDCs for central bank collateral policy is also very much under-researched. This is of crucial importance, since it has direct implications for a risk that central banks fear the most: bank runs. As [OMFIF-IBM \(2019\)](#) puts it, “a CBDC could exacerbate the risk of a system-wide run, though mechanisms exist to prevent this and provide liquidity to a bank in a crisis. For example, there is no upper limit to how much liquidity the central bank can provide, depending on the creditworthiness and collateral of the receiving institution”. Yet, the idea that central banks can limitlessly provide liquidity is counteracted by the very next sentence in that same quote: collateral. Collateral constraint in central banks’ monetary operations means that there, indeed, *is* an upper limit to how much liquidity central banks can provide⁷². [CPMI-MC \(2018\)](#) is one of few exceptions that explicitly, yet concisely, discusses the role of collateral policy and possible related changes in financial conditions as a side effect of CBDCs. Note that, as also emphasized in the previous section, central banks expanding their collateral bases with risky assets is essentially credit allocation. Given that

⁷⁰ One can argue that if CBDCs reduce costs for banks (e.g. costs of AML/CFT regulation), then it might indeed result in more intermediation. But that’s a cost-efficiency, not competition, argument.

⁷¹ Once again, unless new entrants appear who can extend credit.

⁷² Of course, governments issuing new bonds or guaranteeing a private debt, could relax the collateral constraint on central bank operations, but those are decisions beyond the central banks’ remit.

central banks are less efficient in allocating credit, overall efficiency of the financial system could suffer. On this topic, another exception is the speech by First Deputy Governor of the Bank of France, where it is briefly mentioned that “collateral availability would also need to be checked” ([Beau, 2021](#)), when thinking about CBDCs.

Collateral sufficiency issues may be less important if a CBDC take-up is not big enough. According to some calculations of [Group of Central Banks \(2021c\)](#) “[assuming] that CBDC take-up is driven by monthly incomes of people over 14 years old, and three macroeconomic metrics (income distribution, population size, and banks’ share of funding from households), suggests that the domestic demand for CBDC could range between 4% and 12% of bank funding, although these figures would be lower if part of the demand reflected substitution from cash”. Demand for central bank liquidity provision coming from this is probably not big enough for central banks not to be able to satisfy with existing collateral base. However, under some estimates the demand for a CBDC can be as high as 55% of bank funding, which is already too high a number for collateral bases of most (if not all) of central banks. As emphasized in the same report “[w]hile central banks can in principle also be a source of alternative funding, such funding – whether temporary or structural - may need to be provided against lower quality collateral as only that would increase HQLA for banks. The long-term implications of any structural central bank funding as well as the monetary subsidy of funding would need to be carefully considered further” ([Group of Central Banks, 2021c](#)).

5.4. Seigniorage income VS remuneration

Many central banks think that if CBDCs wouldn’t pay interest, this may boost seigniorage income, because it would substitute at least some part of private money, meaning more assets on central bank balance sheet (that generate interest income) as well as more liabilities in the form of CBDCs (that wouldn’t generate interest expenses). However, the relationship between seigniorage income and the rate of remuneration is a bit more subtle. It’s like an optimal choice of price by a monopolistically competitive firm that internalizes the demand schedule. Namely, if money holders are sensitive to interest they earn on their holdings, then it might be optimal (in terms of seigniorage revenues) to remunerate CBDCs just a little bit to attract more people to hold CBDCs (boosting seigniorage). Clearly, this would have to happen at the expense of either private money (deposits and, possibly, stablecoins) or foreign central bank monies (like the USD). As discussed in another section it may be a good thing after all to compete with either stablecoins or foreign monies, but still another section also highlights it may be problematic if CBDCs compete with domestic deposits too much. Hence, the topic of interest rate sensitivity (and its updated estimates) should be taken to the forefront when discussing CBDCs and their implications, especially for people that have a tendency to use foreign currencies as a means of payment or store of value.⁷³

5.5. Account VS token

Some papers have argued that account-based systems, like bank deposits, are too expensive to make micropayments attractive, while token- or value-based approaches that transmit money peer-to-peer in a decentralized way may be more cost-efficient (e.g. [OMFIF-IBM](#),

⁷³ Also worth mentioning here, if a central bank is to make substantial costs for AML/CFT duties, these costs may soon eat away that extra seigniorage.

2019). However, as underlined by [Garratt et al \(2020a\)](#), it's not just "tokenization" that does the job, since digital currencies can be token-based, while also being account-based at the same time (like Bitcoin⁷⁴). It seems that, to make it look like an electronic cash, a CBDC needs to be instant, offline and anonymous. But given the conflicting stories from the account VS token literature, this part of the technology could benefit from a bit more research. In other words, while it seems intuitive to make a clear distinction between a token- and account-based approaches, because one seems to require the verification of an object while the other that of a person (see [Kahn and Roberds, 2008](#) or [Bech and Garratt, 2017](#)), it's not as applicable in electronic money as it is with physical one. Physical notes can be stored anywhere, but digital ones, even when represented as token, require a device, wallet or, well, an account (address). All those latter things will be linked to a person (explicitly or implicitly through pseudonyms like in case of Bitcoin). Hence, while token-based systems are still different from account-based systems, the distinction is much more blurry than usually appreciated.

5.6. Medium of exchange VS store of value

Arguing that CBDCs should function as just medium of exchange may be misleading, since the two functions could be intertwined – a currency may be a good medium of exchange precisely because it's a good store of value or vice-versa. In fact, [Mises \(1949\)](#) argues that "[m]oney is the thing which serves as the generally accepted and commonly used medium of exchange. This is its only function. All the other functions which people ascribe to money are merely particular aspects of its primary and sole function, that of a medium of exchange". If so, the implications of this would be interesting. Namely, if a CBDC with the property of being "a medium of exchange but not a store of value" is not feasible, what does this imply for the incumbent private banks (e.g. financial disintermediation) is important.

5.7. CBDC and exchange rates

The implications of CBDCs for capital flows is also under-researched. This will be important for economies that rely heavily on exchange rate movements. One of few exceptions is [OMFIF-IBM \(2019\)](#), which (only briefly) mentions that during stress times, the presence of a (foreign) CBDC could spark capital outflows from more vulnerable countries, depreciating their exchange rates. In other words, the ease of this happening means that capital flows and, hence, exchange rate movements may become more volatile. See also [Ferrari et al \(2020\)](#).

6. Conclusion

A central bank digital currency is a topic that's most likely only going to gain importance as a couple of nations have recently went live with a retail CBDC system, dozens of them are piloting it and there are even more who actively research the topic. Hence, in this process many studies have already identified several important potential benefits of a CBDC as well as potential risks and costs. As is already well understood a CBDC introduction could have

⁷⁴ As per [Garratt et al \(2020a\)](#), Bitcoin address is an account, while an UTXO is a token.

profound impact on all three monetary policy, financial stability and payment systems fronts. Yet many specific areas remain to be studied even more carefully. This paper tries to thoroughly review all the benefits and risks/costs associated with a CBDC in the current literature as well as to underline the key areas of this topic that need to be researched more. Among the latter is to systematize the three-dimensional linkages between benefits, risks and design choices. Our paper tries to lay some ground to this kind of structured depiction by (i) discussing needed design choices for each item in the list of benefits and risks to-be-mitigated and (ii) overviewing to what other benefits / risk-mitigation aims these design choices may be in conflict with. Other areas discussed above would also significantly benefit from more future research.

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