

IMF STAFF DISCUSSION NOTE

Casting Light on Central Bank Digital Currency

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Authorized for distribution by Tobias Adrian, Martin Muhleisen, and Maurice Obstfeld

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EXECUTIVE SUMMARY

Digitalization is reshaping economic activity, shrinking the role of cash, and spurring new digital forms of money. Central banks have been pondering whether and how to adapt. One possibility is central bank digital currency (CBDC)—a widely accessible digital form of fiat money that could be legal tender. While several central banks have studied the adoption of CBDC and have undertaken pilots, many have not actively explored it and remain skeptical.

This discussion note proposes a conceptual framework to assess the case for CBDC adoption from the perspective of users and central banks. It abstracts from cross-border considerations by assuming that CBDC is for domestic use only. This note discusses possible CBDC designs, and explores potential benefits and costs, with a focus on the impact on monetary policy, financial stability, and integrity. This note also surveys research and pilot studies on CBDC by central banks around the world. The main takeaways are as follows:

- The impact of CBDC introduction will hinge on its design and country-specific characteristics. Critical features will be anonymity (the traceability of transactions), security, transaction limits, and interest earned. The role of cash and commercial bank deposits in payments will also matter.
- CBDC could strengthen the benefits and reduce some of the costs and risks to the payment system and could help encourage financial inclusion. However, demand will not necessarily be very high and will depend on the attractiveness of alternative forms of money. Moreover, there are other payment solutions to help central banks more fully achieve their goals relative to money. CBDC will have to contend with operational risks arising from disruptions and cyberattacks.
- Token-based CBDC—with payments that involve the transfer of an object (namely, a digital token)—could extend some of the attributes of cash to the digital world. CBDC could provide varying degrees of anonymity and immediate settlement. It could thus curtail the development of private forms of anonymous payment but could increase risks to financial integrity. Design features such as size limits on payments in, and holdings of, CBDC would reduce but not eliminate these concerns.
- Account-based CBDC—with payments through the transfer of claims recorded on an account—could make financial intermediation more risky. It would raise funding costs for deposit-taking institutions and facilitate bank runs during periods of distress. Again, careful design and accompanying policies should reduce, but not eliminate, these risks.
- CBDC is unlikely to affect monetary policy transmission significantly, although operations may need adaptation. Transmission could strengthen if CBDC spurs greater financial inclusion. Interest-bearing CBDC would eliminate the effective lower bound on interest rate policy, but only with constraints on the use of cash.

- Overall, it is too early to draw firm conclusions on the net benefits of CBDC. Central banks should consider their specific country circumstances, paying careful attention to the risks and relative merits of alternative solutions. Further analysis of technological feasibility and operational costs is needed.

I. INTRODUCTION

1. **The impact of digitalization is widespread and profound.** It is changing the nature of jobs, education, commerce, innovation, and product life cycles. Demographics are accelerating these developments. Millennials now outnumber baby boomers (Tilford 2018) and are steering the economy toward their world—one in which digital platforms are central, and nearly second nature.
2. **Payments, and more fundamentally money, are also undergoing tremendous change.**² Technology, new employment arrangements, and the growing decentralized service economy, as well as evolving social attitudes, are driving efforts to build new and more decentralized forms of money. These offer peer-to-peer transactions, micropayments, and easy-to-use interfaces integrated with social networks. Payments are increasingly being diverted toward privately run solutions. Even cryptocurrencies such as Bitcoin, Ethereum, and Ripple—still early in their development cycle—offer competing forms of money.
3. **Deep and pressing questions arise.** Is there a role for cash, or a cash-like form of money, in the digital world? Should central banks offer new forms of money? If so, what are the implications for monetary policy and financial intermediation, stability, and integrity?
4. **Central banks are taking these questions seriously.** Several are actively investigating the possibility of a central bank digital currency (CBDC). This new central bank liability would be a widely accessible digital form of fiat money, intended as legal tender. One day, it could fully replace physical cash. CBDC seems to be a natural next step in the evolution of official coinage (from metal-based money, to metal-backed banknotes, to physical fiat money).
5. **This note offers a conceptual framework to evaluate the case for CBDC.** The approach aims to answer a simple question: Does CBDC offer benefits? On the demand side, would it satisfy end user needs better than other forms of money? And on the supply side, would issuing CBDC allow central banks to more effectively satisfy public policy goals, including financial inclusion, operational efficiency, financial stability, monetary policy effectiveness, and financial integrity? In short, is CBDC a desirable form of money given existing and rapidly evolving alternatives? Although its adoption appears more promising in some circumstances than in others, a final decision requires careful evaluation of country-specific circumstances, including a review of technological feasibility and costs. These factors are beyond the scope of this note.
6. **This note includes a summary of pilot projects and analyses from central banks exploring the possibility of issuing CBDC.** The analysis is based on publicly issued materials and discussions with staff members at central banks and technology providers around the world.
7. **This note contributes to a growing body of literature on CBDC.** Others have already explored this topic, including international organizations such as the Bank for International Settlements³ and several central banks (Bank of Canada, People's Bank of China, Bank of England,

² See He and others (2017) for a discussion of the impact of financial technology on financial services.

³ See the report produced by the Bank for International Settlements Committee on Payments and Market Infrastructure (CPMI 2018).

Bank of Finland, Norges Bank, Danmarks Nationalbank, Sveriges Riksbank),⁴ as well as academics and policymakers (Raskin and Yermack 2016; Rogoff 2016; Bordo and Levin 2018; He 2018; He and Khan 2018; Kahn, Rivadeneyra, and Wong 2018). Those analyses discuss the pros and cons of CBDC adoption and, in some cases, make policy recommendations. Relative to those studies, this note makes several contributions. First, it introduces a conceptual framework to evaluate the desirability of CBDC. In doing so, it emphasizes the perspective of users and their preferences for different features of money, in addition to the goals of central banks. Second, it considers policy responses to CBDC adoption to mitigate ensuing risks. Third, it offers a one-stop reference on views and ongoing and future plans of some central banks from around the world regarding CBDC.

8. **The remainder of the note is organized in six sections.** Section II covers the basics of CBDC. Section III lays out a conceptual framework to compare different forms of money from the standpoint of end users and the central bank. Section IV puts the approach to use, evaluating whether there might be a role for CBDC from the perspective of users. Section V considers that question from the viewpoint of central banks, and in so doing explores different options for designing CBDC. Part of this section is devoted to gauging the impact of CBDC on financial integrity, financial stability, and monetary policy transmission. Section VI offers an overview of central bank investigations, and the last section concludes and raises questions for future research on how CBDC might affect cross-border payments.

II. BASICS OF CENTRAL BANK DIGITAL CURRENCY

9. **CBDC is a new form of money, issued digitally by the central bank and intended to serve as legal tender.**⁵ It would differ, however, from other forms of money typically issued by central banks: cash and reserve balances. CBDC designed for retail payments would be widely available. In contrast reserves are available only to selected institutions, mostly banks with accounts at the central bank.⁶ Clearly, CBDC is not intended to have a physical form like cash. But as cash, it would be widely accessible to a country's residents—and potentially to individuals and organizations abroad.⁷ CBDC could be used as easily for person-to-person, person-to-business, and business-to-business transactions of any amount, a notable improvement over cash.⁸ Reserves, by contrast, settle wholesale interbank payments only.

⁴ Fung and Halaburda (2016); Bech and Garratt (2017); Engert and Fung (2017); Davoodalhosseini (2018); Yifei (2018); Carney (2018); Kumhof and Noone (2018); Grym and others (2017); Norges Bank (2018); Gürtler and others (2017); and Sveriges Riksbank (2017).

⁵ Change in legislation may be needed for CBDC to be legal tender. The definition of legal tender—usually applied to banknotes and coins issued by central banks—varies slightly across jurisdictions. For instance, a creditor is not obligated to accept payment in legal tender in all jurisdictions. See He and others (2016) for details.

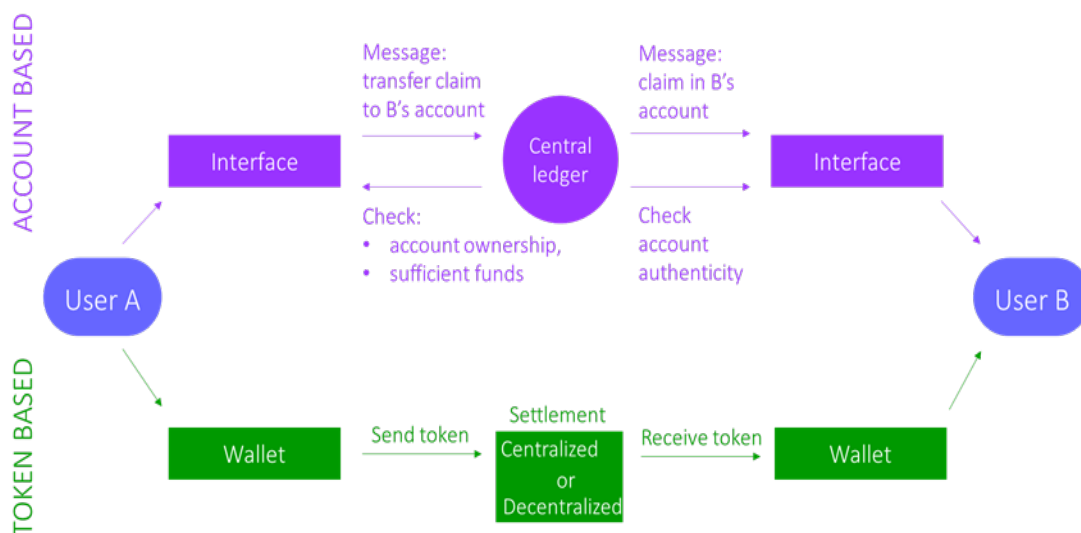
⁶ Reserves can be interpreted as a wholesale form of CBDC used exclusively for interbank payments.

⁷ The cross-border implications of CBDC are not considered here, but some important questions are put forth in the concluding section for future work.

⁸ Person-to-person transactions are deliberately defined as person to person and not peer to peer. The first suggests that payments can be made seamlessly between individuals, such as when splitting a dinner bill. The second,

10. **CBDC could be account- or token-based, the former involving the transfer of a claim on an account and the latter of a token between wallets.**⁹ A transaction in account-based CBDC would resemble today's transactions between commercial bank depositors, except accounts would be held with the central bank. A payer would log in to an account at the central bank—for example, through a web page or an app on a handheld device—and request a transfer of funds to a recipient's account, also at the central bank (Figure 1). The central bank would ensure settlement by updating a master ledger, but only after verification of the payer's authority to use the account, sufficient funds, and authenticity of the payee's account. The exchange of information would therefore be substantial.

Figure 1. Account- and Token-Based CBDC, Basic Mechanics



Source: IMF staff

11. **Transacting in token-based CBDC would involve more steps than exchanging cash but would offer the convenience of not having to meet in person.** Unlike cash—the prime example of a traditional token-based form of money—CBDC tokens would be too complex to be distinguished from counterfeits by parties to the transaction. Settling a transaction using token-based CBDC would require external verification of the tokens. As a result, transactions might not be entirely anonymous, like cash. The extent of anonymity would depend on whether wallets are registered and transaction information is recorded.

however, is often used to denote payments in cryptocurrency for which transaction parties, or “peers,” are also involved in settlement.

⁹ The distinction between accounts (intangible property) and tokens (tangible property) is emphasized in Kahn and Roberds (2009). See also Kahn, Rivadeneyra, and Wong (2018) for a discussion of different forms of token-based CBDC.

12. **Verification of the tokens and settlement could be centralized or decentralized, depending on the technology used.** Decentralized settlement is possible via the use of distributed ledger technology (DLT). However, although the technology is evolving, it currently falls short in scalability, energy efficiency, and payment finality (He and others 2017). DLT could be used over a closed (“permissioned”) network managed by the central bank. But there are other types of centralized settlement technology that may prove more efficient. These would check the validity of the tokens’ serial numbers, then reassign numbers once tokens change wallets to avoid the risk of double spending.

III. A CONCEPTUAL FRAMEWORK TO COMPARE DIFFERENT FORMS OF MONEY

13. **The conceptual framework in this discussion note is geared toward tackling one key question: Does CBDC offer net benefits?** We explore two sides to benefits. First, on the demand side, to what extent might CBDC satisfy end users’ need for money, and would it do so better than other forms of money? Second, on the supply side, would CBDC allow central banks to more fully achieve their public policy goals and overcome specific market failures? In answering these questions and to assess the net benefits of CBDC, we also explore some potential costs and trade-offs associated with its adoption. We refrain, however, from assessing technical implementation costs and feasibility.

14. **The case for CBDC hinges on whether it strengthens the functions of money for users and central banks.** In economics, money is seen as having three functions: a unit of account, a means of payment, and a store of value. As a unit of account, money serves as a measuring stick ideally linked to the same basket of goods over time. As a means of payment, it facilitates transactions. As a secure store of value, it provides refuge from various sources of risk defined further below.¹⁰

15. **Users will seek a form of money that maximizes private benefits and minimizes associated costs and risks.**¹¹ Related criteria are listed below (Figure 2). Emphasis is placed on the means of payment and store of value functions of money, for which criteria are more diverse. The relative weight of each criterion below will vary by country and user.

¹⁰ These three properties are not entirely independent. If money is not a store of value, it will certainly not offer a satisfactory means of payment and will consequently not be a satisfactory unit of account. Money offers substantial efficiency gains by helping coordinate the specification of financial contracts. See He and others (2016) for a discussion of money versus “currency,” a term used for money issued by governments as legal tender.

¹¹ Kahn, Rivadeneyra, and Wong (2018) adopt a similar approach—“convenience, costs, and safety”—in their phrasing.

Figure 2. User Criteria to Judge Different Forms of Money

	Means of payment	Store of value
Maximize benefits	<ul style="list-style-type: none"> • <i>Liquidity</i>: Payment on demand • <i>Scalability</i>: Payment of any size (no limits) • <i>Acceptance</i>: Person to person, person to business, business to business to and from any device; no network limitation • <i>Extra services</i>: Preferential access to other financial services (loans, advice, etc.) 	<ul style="list-style-type: none"> • <i>Returns</i>: Nominal interest payments¹²
Minimize costs	<ul style="list-style-type: none"> • <i>Transaction</i>: Ease of use; fees • <i>Disclosure</i>: Degree of anonymity 	
Minimize risks	<ul style="list-style-type: none"> • <i>Settlement</i>: Lag between agreeing to a transaction and actual receipt of funds 	<ul style="list-style-type: none"> • <i>Theft</i>: Ability to reverse fraudulent transactions, exposure to fraud/cyber risk • <i>Loss</i>: Ability to claim ownership or recover access if lost • <i>Default</i>: of the money issuer

16. One important criterion stands out: the ability to make anonymous transactions.

Regarding money, anonymity covers the extent to which identity and transactions are, or can be, disclosed to transaction parties, third parties, and the government. There are legitimate reasons people may prefer at least some degree of anonymity—potentially when it comes to everyone except the government, and regarding the government unless a court order unlocks encrypted transaction information. It is a way to avoid customer profiling—commercial use of personal information, for example, to charge higher mortgage rates to people who purchase alcohol. Another advantage of anonymity is limiting exposure to hacking. Moreover, anonymity is often associated with privacy—widely recognized as a human right (as stated in the Universal Declaration of Human Rights [Article 12] and elsewhere).

17. On the supply side, central banks play a pivotal role and ensure that money delivers on its three functions. For central banks, this role means two things. First, because they are accountable to the public, central banks must design the money they issue—and regulate private forms of money—in a way that satisfies the user needs stated earlier. Second, because they are public policy institutions, they must ensure that money also meets important social criteria (illustrated in Figure 3 and discussed in Box 1):

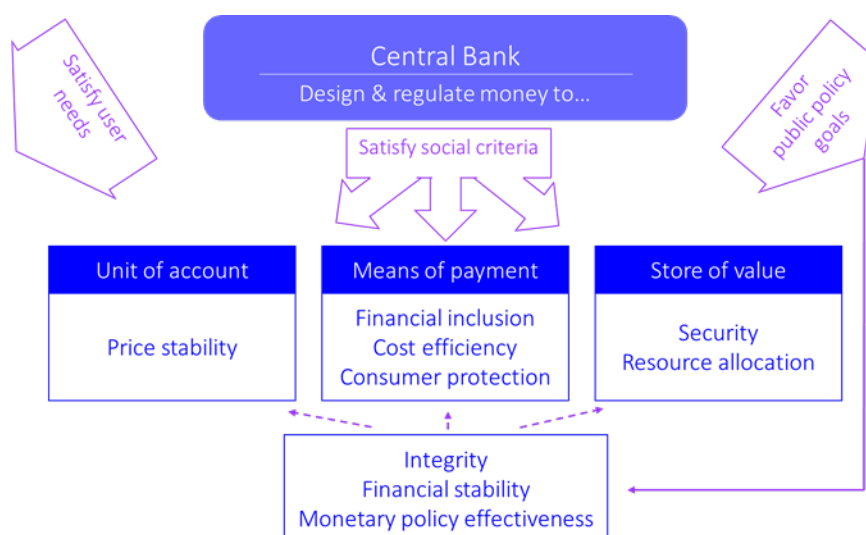
- As a *unit of account*, money is an important public good that requires price stability in all economic circumstances. The design of money can favor or interfere with this goal. For instance, because cash pays no interest, central banks find it difficult to offer deeply negative interest rates following sharp recessions (more on this later).

¹² Bordo and Levin (2018) argue that for money to be a secure store of value, it must offer risk-free returns.

- As a *means of payment*, money must be universally available and verifiable as well as efficient, while ensuring appropriate consumer protection and minimal cost to taxpayers.
- As a *store of value*, money must be as secure as possible, but it must also allow for efficient allocation of resources.

18. **In addition, central banks will prefer forms of money that support, or at least do not undermine, three other public policy goals: financial integrity, financial stability, and monetary policy effectiveness.**¹³ In turn, each of these further supports the three functions of money. Financial integrity covers, among other things, anti-money laundering and combating the financing of terrorism (AML/CFT) rules, including customer due diligence measures and additional measures aimed at fighting corruption and fostering good governance.

Figure 3. The Central Bank's Criteria to Evaluate Different Forms of Money



Box 1. The Birth of Central Banking—a Quest for Efficient, Low-Cost, and Safe Money

There is a fascinating historical account of the birth of central banking in Europe in Kahn, Quinn, and Roberds (2014). Coins were the predominant form of money in medieval times and during the early Renaissance. Although they were a relatively efficient means of payment and allowed immediate settlement, transportation costs grew substantially as commerce spread geographically. Bills of exchange were introduced to decrease these costs; merchants could purchase bills drawn on the foreign banks where they intended to do business. However, bills carried substantial counterparty risk, as debtor banks often did not pay. The Bank of Amsterdam was established in 1609 to reduce the risks inherent in bills of

¹³ Other goals of central banks regarding CBDC include measures to stem the loss of seigniorage from the growth of new forms of private money. CBDC would in fact preserve seigniorage and possibly increase it if the central bank's balance sheet grew, depending on whether CBDC earned interest. However, because seigniorage is small in many countries, we do not entertain this line of argument further.

exchange, following earlier (though smaller-scale and private) models, such as the Taula de Canvi in Barcelona (1401), Banco di San Giorgio in Genoa (1408), and Banco di Rialto in Venice (1587). The Bank of Amsterdam stood ready to pay high-quality Dutch guilders against the receipt of bills. In 1683, it offered account balances to settle bills of exchange on its books, and soon thereafter suspended the right of coin withdrawals entirely, thereby shifting the unit of account from commodity money to its liabilities, as in a system with metal-backed banknotes. At its peak in the mid-1700s, yearly turnover through the accounts at the Bank of Amsterdam was more than 2.5 times Dutch GDP.

This evolution highlights ongoing efforts to establish increasingly efficient, secure, and lower-cost forms of money. The Bank of Amsterdam first reduced the risks and costs of payments by offering immediate and final settlement. Then it did more by offering liquidity backstops to merchant banks that were funded with bills of exchange. Without this backstop, merchant banks would have faced a trade-off. They either had to offer a secure store of value by storing the cash received for their bills of exchange or efficiently allocate funds by lending the cash. This would expose them and their creditors to the liquidity risk associated with maturity mismatches. The Bank of Amsterdam's innovation underscores the role of the state in enhancing the safety of private payment systems without contravening their efficiency. Bank supervision, lender of last resort functions, and deposit insurance do much the same today.

19. **The last leg of the conceptual framework is to determine competitors to CBDC.** These fall into four categories, but will vary by country: cash, commercial bank deposits, narrow finance, and cryptocurrencies. All except cash are evolving and rapidly gaining market share.

20. **Commercial bank deposits are going through notable improvements.** Payments have traditionally been facilitated by debit card networks. Today, two continuing transformations are notable, especially in advanced economies. The first stems from "wrapper" technology, such as Venmo in the United States, which allows transactions to take place between mobile devices (bypassing expensive point-of-sale terminals) and adds a layer of security.¹⁴ The other is central-bank-provided fast-payment solutions ("fast payments").¹⁵ These allow payments of any size and type (person to person, person to business, business to business) to be settled instantaneously by the central bank in reserve money through a dedicated platform running continuously at negligible cost.¹⁶

¹⁴ Touchless technology also facilitates debit card transactions. There is wrapper technology, such as PayPal, for credit card transactions as well, but credit-based transactions lie outside the scope of this note.

¹⁵ The largest-scale project is the European Central Bank's Target Instant Payment Settlement service, to be introduced in November 2018. There are already other similar initiatives, such as Hong Kong SAR's Faster Payments introduced in August 2018, Sweden's Swish, Denmark's Straksclearing, and Australia's New Payments Platform. Other so-called fast or instant payment solutions are also being rolled out exclusively by commercial banks (see CPMI 2016).

¹⁶ Fast payments can be thought of as a form of CBDC offered through a public-private partnership, because they allow people to settle in central bank reserves at will, at any time, through banks (resembling the proposal in Bordo and Levin 2018). The central bank, then, offers the means of payment function of money and banks the store of value function. Together, they offer money's three functions. From a technological standpoint, fast payments would however differ, even if account-based. Fast-payment engines are optimized for interoperability with real-time gross

21. **“Narrow finance solutions” is a term introduced in this discussion note to capture the various new forms of private money backed one for one by central bank liabilities, either cash or reserves.** These offer stable nominal value, security, liquidity, and potentially close to a risk-free rate of return. The parallel here is with currency boards (such as in Hong Kong SAR) or metal-backed banknote systems (such as the gold standard). Two versions of narrow finance solutions are relevant. The first is *stored value facilities*¹⁷ such as AliPay and WePay in China, PayTM in India, M-Pesa in Kenya, and Bitt.com in the Caribbean. These provide *private e-money* to users against funds received and placed in custodian accounts. Transactions occur between electronic wallets installed on handheld devices, can be of any size (although they are usually not large), and are centrally cleared, but are restricted to participants in the same network. However, holding these forms of money entails some risk.¹⁸ Nonetheless, this segment is gaining widespread and very rapid acceptance. The second version of narrow finance solutions—*narrow banks*—is only beginning to materialize. It covers institutions that invest client funds only in highly liquid and safe government assets—such as excess reserves at the central bank—and do not lend. However, they allow payments in their liabilities through debit cards or privately issued digital money.¹⁹

22. **Cryptocurrencies are different along many dimensions and struggle to fully satisfy the functions of money, in part because of erratic valuations.** Examples include Bitcoin, Ethereum, and Ripple. These currencies are not the liability of any institution and are not backed by assets. Their value is usually volatile, because most have rigid issuance rules. Some new cryptocurrencies attempt to stabilize their value by controlling issuance according to a function of price deviations from a fiat currency or commodity (as in an exchange rate peg). Examples are Basecoin and Stablecoin.²⁰ In all cases, transactions are settled in a decentralized fashion, using distributed ledger technology.

settlement systems (in which banks keep liquidity and borrow funds to settle intraday payments) and, by extension, with private banks. This integration would not be necessary for account-based CBDC.

¹⁷ The terms “stored value facilities” and “e-money” are taken from the Monetary Authority of Singapore (2017); e-money is defined as “electronically stored monetary value in a payment account that can be used to purchase goods or services, or to transfer funds to another individual.”

¹⁸ These depend on whether the stored value facility has access to the funds in the custodian account and whether it can invest them in illiquid assets and the degree to which e-money issuance can exceed reserves. Both of these examples invite the question of why users would choose to exchange or forgo a safe and liquid asset like cash or a government bond for another provided by a private intermediary. The answer lies in the ease with which users can initiate payments on private platforms, and potentially access other services. Note that new players—such as large tech firms, including Amazon, Apple, Google, and Facebook—may well enter this space. They could offer e-money to purchase their goods at a discount, in exchange for valuable information.

¹⁹ See Ali (2018) for instance for a solution based on privately issued digital money. Note that firms in the narrow finance category do not create money, unlike fractional reserve banks. In a world of CBDC alone, only the central bank could create money. Today most money creation is “outsourced” to commercial banks, which create deposits when they extend credit. The process of money creation nonetheless responds to interest rates set by central banks.

²⁰ See, however, Eichengreen (2018) for doubts about the ability to maintain a peg, short of full backing by fiat currency as in the narrow finance example (referred to as a currency board).

IV. IS THERE A ROLE FOR CBDC? USER PERSPECTIVE

23. **Competing forms of money can be ranked according to the criteria described earlier.**

The evaluation is presented visually in Figure A1.1 of Appendix I, in the form of “spider charts,” and explanations are provided in the subsequent Table A1.1. Higher scores are captured by points farther from the center. The more attractive the form of money, the larger the surface covered by the spider chart. All monies were deemed liquid, so that criterion was left aside.

- *Cash* is not an especially attractive means of payment given its high transaction costs (the need to meet in person and withdraw cash, which may be difficult in remote locations), vulnerability to theft, and lack of returns in the form of interest. However, cash offers immediate settlement, no default or cyber risk, and—importantly—full anonymity, a potentially attractive feature to users.
- *Cryptocurrencies* are the least attractive option, receiving a low score in settlement speed because of current technological limitations (which may eventually be overcome). Their main advantage is anonymity.
- *Private e-money* provided by *stored value facilities* scores high on several fronts. It offers widespread acceptance, low transaction costs via user-friendly interfaces designed by customer-centric firms, and full-service bundling with other financial as well as social services. *Narrow banks* could further reduce default risk—and possibly enhance scalability by offering larger-value payments, although potentially lower ease of use, depending on design.
- *Commercial bank deposits*, as they were traditionally structured, offered average value. On the positive side, they provided security from theft and loss, and integration with additional services, while on the negative side there was limited acceptance (cumbersome peer-to-peer payments requiring checks or wire transfers) and scalability (floors on debit card payments). However, recent reforms and innovations, including *fast payments*, have improved the attractiveness of commercial bank deposits considerably. Deposits with fast payment are completely scalable and are widely accepted, without network limits, have no settlement risk, and offer limited default risk where deposit insurance is available.²¹ Transaction costs (fees and ease of use) are minimal.

24. **CBDC would not strictly dominate any of these alternative forms of money.** As evident in Figure A1.1, CBDC would closely compete with evolving commercial bank deposits and e-money. CBDC stands out only when it comes to anonymity and default risk. There are two sets of features: fixed features, for which the central bank does not have discretion, and flexible features.

- *Fixed design features*: CBDC would be on par with fast-payment solutions regarding acceptance (person to person, person to business, business to business without network restrictions), settlement risk, and transaction cost (to the extent that mobile interfaces are well designed—no small feat). CBDC would probably be superior regarding default risk, although in many jurisdictions only marginally. Instead, CBDC would score poorly in terms of offering additional

²¹ Insurance limits nonetheless should ensure that funds earmarked for payments—not all those held as savings—are protected. Households—large firms to a lesser degree—have the option of splitting deposits across accounts.

services (although banks could provide the front-end applications to manage CBDC and could cross-sell services).

- *Flexible design features:* CBDC could offer competitive interest returns, protection from theft and loss, scalability, and anonymity, though not all at once as these features depend on one another. As discussed earlier, anonymity could be provided to different degrees: relative to transaction parties, third parties, and/or the government. But the greater the anonymity, the harder it is to reverse fraudulent transactions (risk of theft) and claim ownership (risk of loss). And central banks may be prepared to offer full anonymity only with strict and low limits on CBDC holdings, thus undermining scalability. Finally, CBDC could offer interest. If it paid the policy rate, it would be as attractive as narrow finance solutions, although commercial banks could still offer higher rates on deposits (and recoup profits by charging higher lending rates—more on this later).

25. **In summary, demand for CBDC will depend on its design. It may not be high in more advanced economies, except as a cash replacement, but could be very attractive elsewhere.** Commercial bank deposits with fast payments, and to some extent narrow banking solutions, will rival CBDC and could be superior in some areas. CBDC could excel only regarding anonymity, although at some cost to scalability and security. As such, it would compete mostly with cash, by allowing small-value transactions with at least some degree of anonymity. Someday CBDC may, indeed, be introduced as a replacement for paper bills, which will become increasingly anachronistic as economic activity grows ever more digital. However, in jurisdictions with limited banking penetration and unreliable settlement platforms, CBDC may be more attractive to users, especially in the absence of stored value facilities.

V. IS THERE A ROLE FOR CBDC? CENTRAL BANK PERSPECTIVE

26. **This section gauges whether central banks could benefit from CBDC to more fully achieve public policy goals.** These include satisfying the social dimensions of money's three functions, as well as financial integrity, financial stability, and monetary policy effectiveness.

Social Criteria for Money

27. **CBDC is unlikely to offer near-term assurance of price stability in all economic circumstances—as needed to bolster the *unit of account* function of money.** The global financial crisis starkly illustrated that interest rate policy can be constrained by the presence of cash. Policy rates cannot be brought significantly below zero without risking a massive shift into cash, which ensures zero returns (see Dell'Ariccia and others (2017) for a full discussion and Habermeier and others (2013) for an overview of unconventional monetary policy). However, cash is unlikely to go away anytime soon, for political reasons. Only over the longer term, if CBDC is adopted widely, would cash be eliminated, much as happened with metal coinage. In that scenario, policy rates could go deep into negative territory. But this would happen only to the extent that CBDC also charged negative rates and did not replace cash as a means to circumvent policy. In the interim, other

measures have been proposed to allow for deeply negative policy rates, but with questionable feasibility and without necessarily requiring CBDC.²²

28. **CBDC could help ensure equal access to a *means of payment* for all citizens, thereby favoring financial inclusion. But other solutions also exist and may be more efficient.** Much depends on the barriers to financial inclusion. For one, cash may be difficult to obtain and use in underpopulated and rural areas. As a majority of the population shifts to digital forms of money, the infrastructure for cash (such as distribution networks, counting machines, and armored services) may deteriorate, and businesses may resist dealing with it. As in other cases of negative externalities, government intervention may be warranted. One approach may involve subsidizing the provision of cash in underserved areas. CBDC may not be a viable solution if access to technology is limited. If the problem is instead the supply of bank accounts—which banks deem unprofitable or require unaffordable or nonexistent technology—the question is whether the private sector can offer alternative solutions. M-Pesa in Kenya and PayTM in India are examples of successful initiatives, although with some state support in the case of M-Pesa (from the UK Department for International Development). Alternatively, the government could subsidize the deployment of bank branches. Or—short of direct intervention—it could facilitate the development of online banking and communication infrastructure in rural areas and reduce the cost of bank-intermediated small-value transactions by deploying fast payments. Where these solutions are not feasible, CBDC could provide an alternative. If, however, barriers to financial inclusion stem from an aversion to formalization, neither CBDC nor other initiatives would prove satisfactory.

29. **CBDC may instead help reduce costs associated with the provision of cash, thereby ensuring an *efficient means of payment* from a public policy perspective.** Issuing and managing cash are expensive. Hasan, De Renzis, Schmiedel (2013) estimate the cost to be 0.5 percent of GDP for the euro area, similar to the cost in Canada (Kosse and others 2017) and Uruguay (Alvez, Lluberas, and Ponce 2018). Costs fall mostly on banks, firms, and households. Although introducing and maintaining CBDC would probably entail substantial fixed costs, marginal operational costs would likely be low, despite the need for customer service. On this basis alone, the business case to adopt CBDC would probably be better for larger jurisdictions able to absorb the fixed costs.

30. **CBDC would not help resolve the tension central banks face between offering a *secure store of value* and promoting financial intermediation.** Narrow finance solutions offer a liquid and secure store of value at the cost of financial intermediation. This is because payments must be entirely prefunded, as explained earlier. Fractional reserve banks, however, pool the liquidity buffers households and firms maintain to respond to payment shocks. And because not all shocks materialize at once (at least not most of the time), they can lend a portion of the funds, keeping only

²² Cash could be prohibited altogether as argued in Rogoff (2014), made costly to hold as suggested in Bordo and Levin (2018), or made to depreciate against CBDC, which would become the sole legal tender, as in Agarwal and Kimball (2015). Note that if CBDC were not interest bearing, the effective lower bound could bind at even higher rates of interest, as CBDC could be stored more cheaply than cash. CBDC has also been touted as a means to implement aggressive monetary stimulus known as a “helicopter drop” by crediting CBDC accounts or wallets holding CBDC tokens. However, doing so would not necessarily reach all citizens. Moreover, the issue of legitimacy remains: how does the central bank decide how much to transfer to each household given the notable and very explicit redistributive consequences? Finally, helicopter drops would continue to be viewed as a form of monetary financing, thus undermining central bank independence.

a *fraction* in highly liquid and safe assets. Even though central banks should be concerned if narrow banking solutions grow substantially, CBDC would not help reverse the trend. CBDC is also, after all, a form of money that requires full prefunding. Instead, fast payments would help fractional reserve banks offer money that competes with that offered by stored value facilities and other narrow finance solutions.

31. **Other potential benefits of CBDC must be seen against the backdrop of a reduction in the use of cash.** The trend is already evident in some countries and is expected to become more widespread. Sweden is probably the most striking example.²³ In other countries, cash in circulation as a share of GDP has actually increased in the past decade, as documented in Bech and others (2018). However, a second look reveals that such movements are largely cyclical and can be partly explained by low interest rates. As shown in Box 2, the preference for cash has mostly been decreasing or has remained unchanged except in reserve currency countries (Switzerland and the United States). In addition, the demand for cash is likely to diminish as older generations give way to more technology-adept generations. Merchants and banks in both advanced and developing economies are also trying to discourage cash transactions, given the related costs.

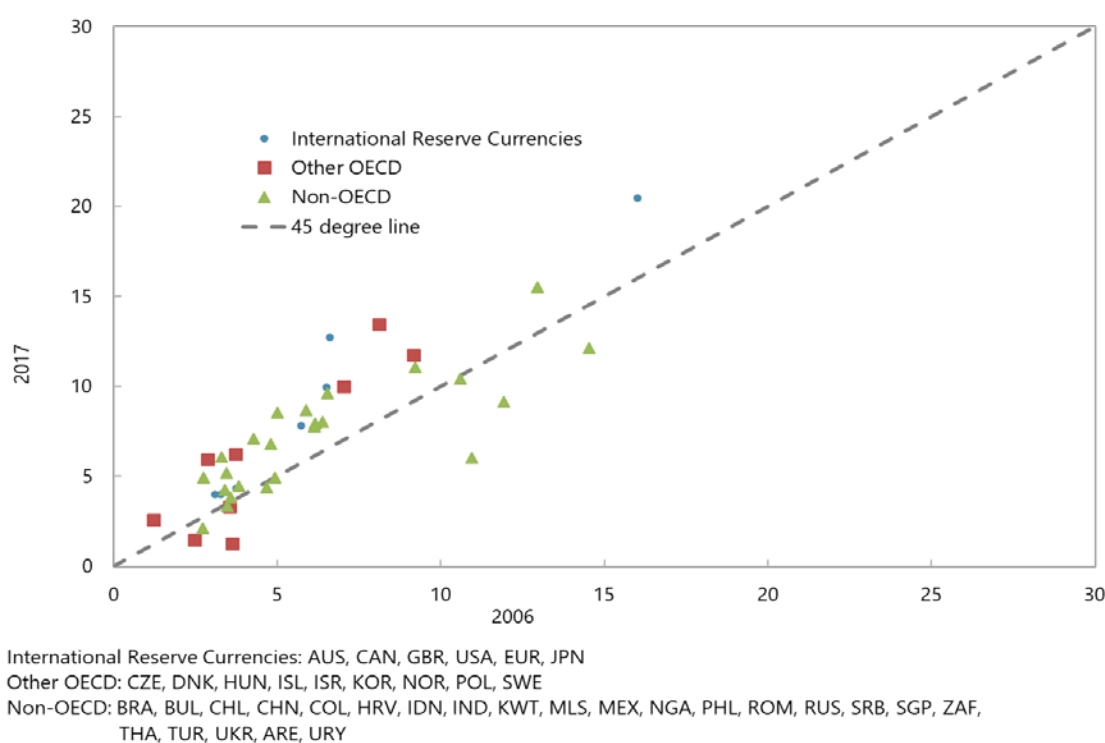
²³ Cash in circulation as a share of GDP is currently half its value 10 years ago, representing merely 6 percent of central bank liabilities and 2 percent of the money supply.

Box 2. A Closer Look at the Demand for Cash

In many countries, currency in circulation has increased significantly in the past decade (Figure 4a).²⁴ However, much of that increase seems cyclical, because it can be explained in good part by lower interest rates, higher uncertainty, and economic recoveries.²⁵ Figure 4b shows that in selected countries the unexplained (residual) component of cash in circulation—loosely associated with preferences—has often decreased or remained stable. Only in Switzerland and the United States has this component increased markedly over the past decade, in part thanks to those countries' reserve currency status.

However, cash still accounts for a large share of transaction volumes, though not of value, even in advanced economies. The use of cash is subject to habit, increases with age, and decreases with education and income. It is generally lowest in countries with the most developed payment systems.²⁶

Figure 4a. Cash in Circulation
(as percent of GDP)



Source: IFS, Haver

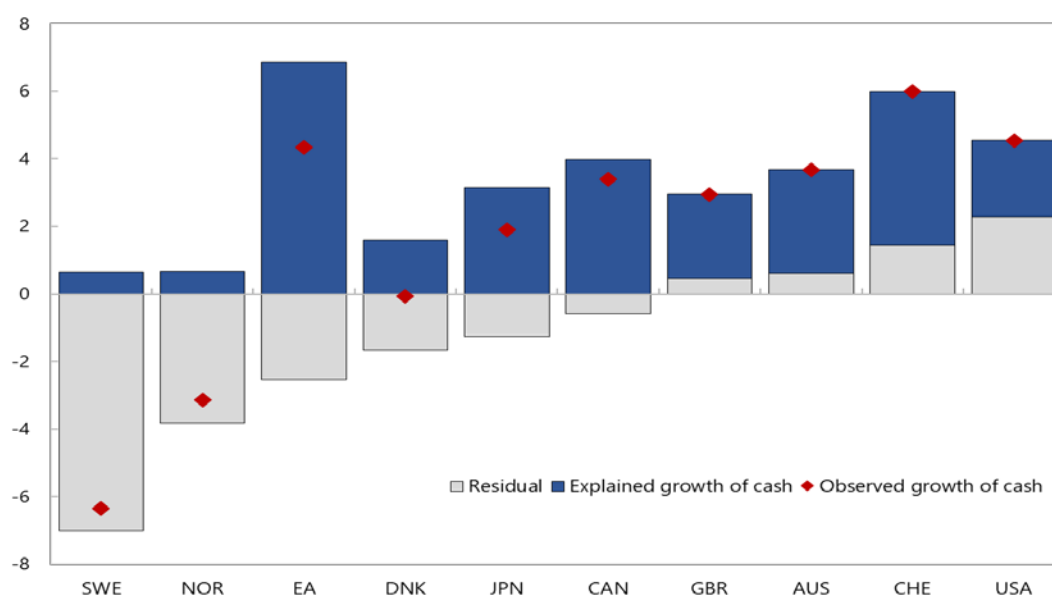
²⁴ See also Bech and others (2018) and Jobst and Stix (2017).

²⁵ The baseline is a regression of the log of real cash in circulation on deposit rates and the log of real GDP. Results are robust to inclusion of the log of stock prices (to capture wealth effects), different measures of uncertainty (Chicago Board Options Exchange Volatility Index and uncertainty indices), and country-by-country and panel estimates.

²⁶ For related analysis, see Flannigan and Parsons (2018); Arango-Arango and others (2018); Esselink and Hernández (2017); Wakamori and Welte (2017); Bagnall, Bounie, and Huynh (2016); Krüger (2016); Bennet, Schuh, and Schwartz (2014); and Sisak (2011). For example, the cash share of payments is 82 percent by volume in Austria (63 percent by value), but 46 percent in the United States (23 percent by value).

Figure 4b. Growth of Real Cash Balances

(in percent, annualized growth rates)



Sources: Staff calculations

32. **As the use of cash wanes, there is greater concern about the security of the payment system if it is dominated by private firms. But there are solutions other than CBDC.** Private issuers of money, including rapidly growing stored value facilities, may not internalize the social cost of systemic disruptions from cyberattacks or negligence, and thus may not adequately invest in security (to the extent that users remain oblivious to these risks and do not require sufficient safeguards). Central banks would be more prone to do so, but that does not mean that the risk of cyberattacks would disappear. Moreover, CBDC could offer a backup solution if disruptions in the digital infrastructure materialize, unless there are large-scale natural disasters and power outages. (Cash is similarly at risk since its infrastructure also requires electricity.) Another solution is to deploy fast payments, which also give central banks control over an essential piece of the payment architecture. Finally, adequate regulation should also bolster the security of money, even if privately provided.

33. **The disappearance of cash could also pose risks to consumer protection. Again, CBDC can help, but so would fast payments and regulation.** Modern payment systems are often operated by a few commercial banks and by even fewer clearinghouses and messaging services. Payment systems tend to become natural monopolies. This reflects strong network externalities (the value of using a given payment network is greater the larger the user community), decreasing average costs (savings from netting transactions over a large user base), high fixed development and maintenance costs, and significant gains from aggregating data, which—to an individual—is

worth little. However, private monopolistic providers will tend to offer inadequate and expensive services and could take unfair advantage of data. The prevalence of cash as an attractive and low-cost competitor may have limited the monopoly power of private monies. In the future, if antitrust regulation and data protection prove insufficient, CBDC could serve that same purpose. However, so too could the deployment of low-cost fast payments.

34. **In summary, while central banks could benefit from CBDC to more fully satisfy some of the social criteria of money, in many countries there are also other solutions.** CBDC may be a way to reduce the cost to society associated with the use of cash. Financial inclusion may also benefit, if private sector solutions and policy efforts do not bear fruit. However, CBDC will not support efficient allocation of resources. It could, under some circumstances, help central banks bolster the security of payment systems and consumer protection. But regulation and, where possible, fast-payment platforms should offer compelling alternatives.

Can CBDC Balance Privacy and Financial Integrity Concerns?

35. **In designing money, national authorities already face a trade-off between satisfying legitimate user preferences for privacy and mitigating risks to financial integrity.** Cash protects privacy because it is anonymous: no account is necessary, and there is no record of transactions. However, it also facilitates criminal financial transactions such as money laundering, financing of terrorism, corruption, and tax evasion. Most of the cash in circulation is in the top two largest denominations, often associated with illicit payments or store of value.²⁷

36. **Recent discussions on the trade-off between financial integrity and privacy for cash could prove useful for CBDC design.** Eliminating cash would undermine privacy. Moreover, it is unlikely to improve financial integrity since illicit transactions would presumably migrate to another form of money (McAndrews 2017). Ironically, those seeking anonymity for legitimate purposes might even adopt the parallel money, contributing to its liquidity and attractiveness for criminal use. This pattern may be visible in the adoption of cryptocurrencies. Proposals to do away with high-denomination bills seem more appealing (Rogoff 2016 and references therein). Remaining small-denomination bills could in part satisfy legitimate preferences for privacy but would pose risks for illicit transactions.

37. **Depending on its design, CBDC can strengthen or undermine financial integrity.** Financial integrity could be strengthened if authorities impose strict limits on the size of transactions. Alternatively, CBDC can be designed to facilitate effective identity authentication and tracking of payments and transfers. Identities would be authenticated through customer due diligence procedures, and transactions recorded. But unless required by law, users' information could be protected from disclosure to third parties and governments, while criminals could be deterred by the risk of investigation and prosecution. Although promising on paper, these solutions would have to be further evaluated, and questions answered. For instance, Would users trust the safeguards established to protect their privacy? Would central banks be held responsible for

²⁷ Judson (2017); sample includes Australia, Brazil, Canada, the euro area, Hong Kong SAR, India, Japan, Mexico, Singapore, South Arabia, South Korea, Sweden, Switzerland, Turkey, Russia, the United Kingdom, and the United States. See also Europol (2015).

compliance failures, even if customer due diligence procedures were outsourced? And to what extent could authorities benefit from the ability to scrutinize transaction information for illicit activity in real time? On the other hand, CBDC offering full anonymity and large-value transactions would undermine financial integrity relative to cash and current noncash fund transfer systems. Whatever design is chosen, it should accommodate the implementation of effective AML/CFT measures.

Would CBDC Undermine Financial Stability and Banking Intermediation?

38. **CBDC could affect financial stability and banking intermediation if it competes with bank deposits.** Hence, in what follows we assume CBDC with characteristics similar to those of bank deposits: traceability and protection from loss or theft. In a world of diverse consumers, it is reasonable to assume that some will prefer and adopt CBDC.

39. **Two hypothetical scenarios are considered.** The first is a tranquil period following the introduction of CBDC. Questions arise such as how banks will respond, what will happen to bank intermediation and funding, and how central banks might react. The second scenario assumes a period of systemic financial stress in a world with CBDC. The key question in this case is what happens to run risk—the potential for a significant shift of deposits from banks to CBDC.

Scenario 1: Risk of Disintermediation in Tranquil Times

40. **Banks will likely react to the introduction of CBDC, but their ability to defend their business model depends on market power.** As some depositors leave banks in favor of CBDC, banks could increase deposit interest rates to make them more attractive.²⁸ But the higher deposit rates would reduce banks' interest margins. As a result, banks would attempt to increase lending rates, though at the cost of loan demand.²⁹ The greater banks' market power, the less demand for credit would contract and the more effectively banks could respond to CBDC by preserving profits (see Box 3).

Box 3. Banks' Response to CBDC—Higher Rates on Deposits and Lending³⁰

The introduction of CBDC draws deposits away from banks, leading to an upward shift in the deposit supply curve (Figure 5a). Banks counteract some of the impact on their deposit bases by raising deposit interest rates. Moreover, banks pass part of this deposit rate hike on to their loan interest rates. When banks have more market power (reflected in the steepness of the demand curve in Figure 5b), they can better insulate their profits by passing the deposit rate hike on to loan rates. Banks with little market

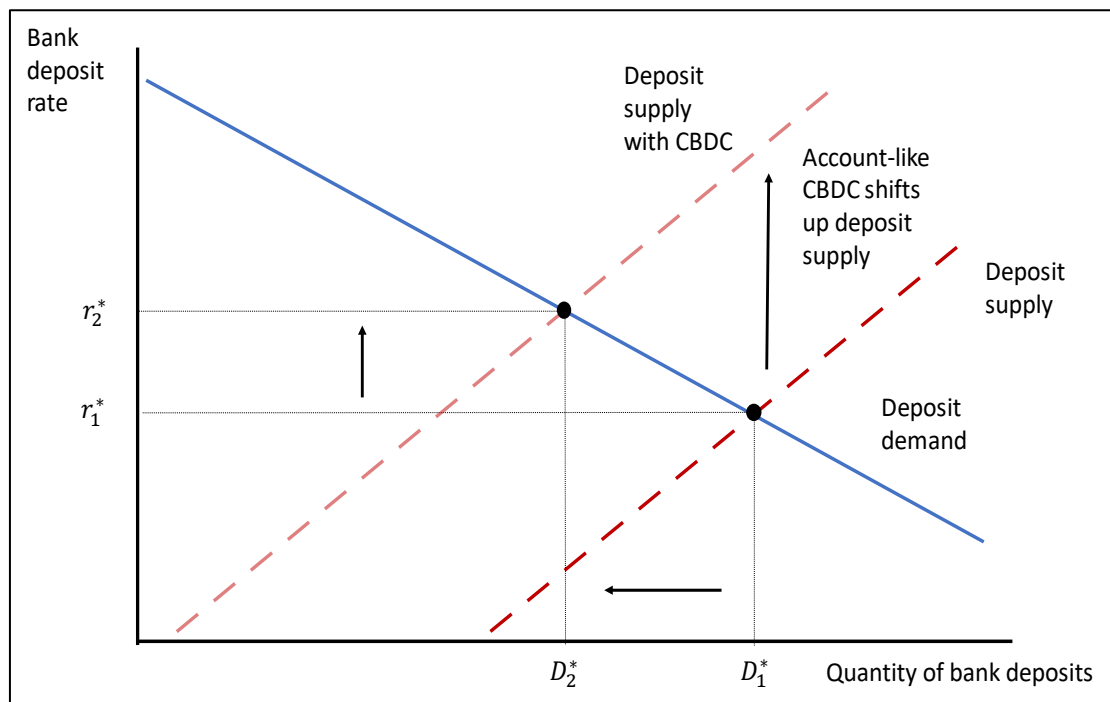
²⁸ Banks could also respond by providing more and better complementary financial services.

²⁹ In addition, central banks could lower policy rates to counter the tighter financial conditions stemming from banks' higher lending rates, so that the banks' response to CBDC would be less contractionary for the economy. Moreover, the net impact of CBDC adoption on interest rates will depend on how the central banks introduce the CBDC, where an injection of CBDC via the sale of government bonds could, under specific circumstances, lead to lower rates (Barrdear and Kumhof 2016).

³⁰ This discussion of the reaction of banks to CBDC adoption is based on a model by Agur and others (forthcoming) assuming an oligopolistic market structure in lending markets.

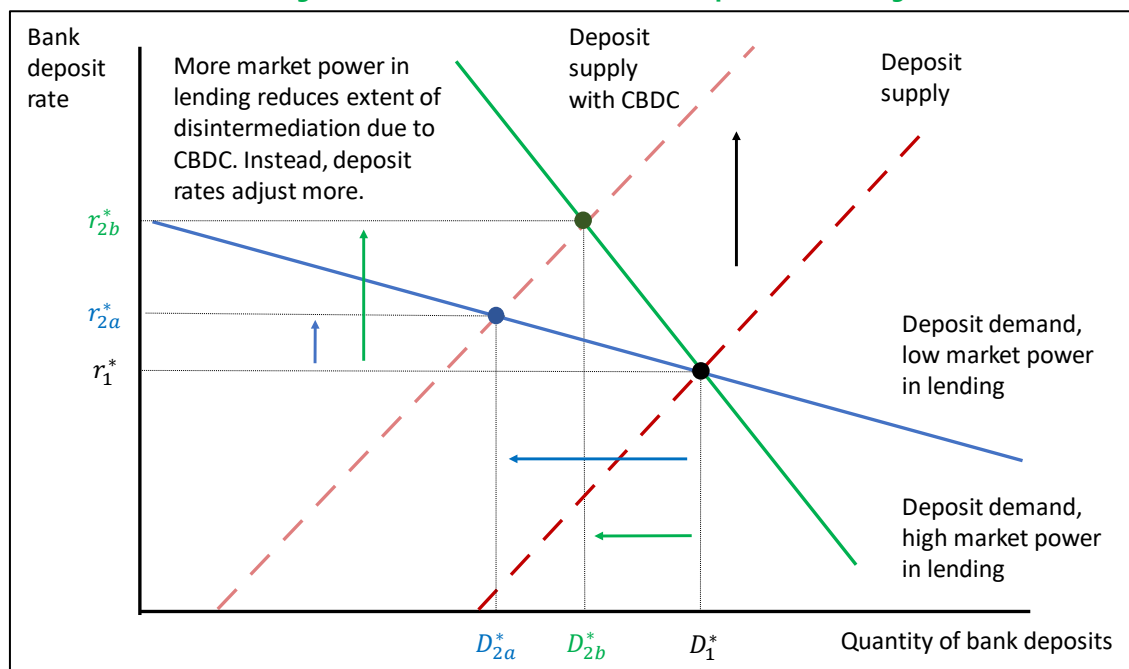
power adjust more aggressively in quantity, exhibiting a larger contraction in deposit and loan volume (Figure 5b).

Figure 5a. Introduction of CBDC



Source: IMF staff

Figure 5b. Effects of CBDC and market power in lending



Source: IMF staff

41. **Banks could try to replace the deposits that shift to CBDC with other forms of funding.** Potential alternatives are commercial paper, bonds, and equity. All are market (wholesale) types of funding. There are three likely implications to such a shift.

42. **First, bank funding would become more expensive.** Deposit insurance and implicit government guarantees allow banks to fund themselves with deposits at lower cost than with other instruments.³¹ Hence, switching away from deposits could result in lower bank profits or higher lending rates to preserve margins. The magnitude of the effect may not be enormous, though, given that most of the value of deposits in most banking systems is uninsured.

43. **Second, the introduction of CBDC may affect market discipline in the banking sector.** Discipline stems from banks facing higher costs of funding or a drop in deposits as they take more risks (Berger 1991). However, insured depositors do not impose discipline on banks since they do not bear the consequences of the risks they undertake. Following the introduction of CBDC, market discipline could decline (increase) if banks lose more (fewer) uninsured than insured depositors. If market discipline diminishes, banks could take on more risk.

44. **Third, bank funding may become less stable.** Retail depositors are more stable sources of funding than wholesale depositors (see Huang and Ratnovski 2011; Gertler, Kiyotaki, and Prestipino 2016). If more (fewer) retail depositors prefer CBDC to wholesale depositors, bank funding could become more (less) volatile. In that case, banks might have to hold more liquid assets to meet regulatory requirements or cut back on lending.

45. **The extent of disintermediation will be greater among banks in more direct competition with CBDC.** CBDC would likely be in greater competition with retail than with wholesale deposits, which require larger-value payments. Thus, banks with a larger share of retail deposits will face tougher competition following the introduction of CBDC and may not be able to raise lending rates to preserve profits. Greater presence of nonbank loan providers would add to competitive pressure on banks.

46. **In the event of disintermediation, central banks can respond in several ways, although some are not especially palatable over the medium term and would imply a dramatic step away from central banks' typical mandates.** The central bank could limit the decline in bank deposits and lending by setting limits on individual CBDC holdings or discouraging (such as through fees) convertibility from bank deposits to CBDC. In addition, the central bank could lend the funds diverted from deposits back to banks. This would allow banks to keep lending, although the central bank could require more capital or collateral, with possible implications for the cost and volume of

³¹ Ueda and di Mauro (2013) estimate that government guarantees have reduced bank funding costs between 60 and 80 basis points in recent decades. Other studies quantify the impact of government guarantees on bank funding costs by analyzing funding cost differentials for banks deemed too big to fail (Tsesmelidakis and Merton 2013; Acharya, Anginer, and Warburton 2016; Kelly, Lustig, and van Nieuwerburgh 2016; Kroszner 2016).

lending. Moreover, the central bank's balance sheet would grow, it would systematically take on credit risk, and it would have to decide how to allocate funds across banks.³²

47. **At the margin, central banks could help maintain the ties between customers and banks by allowing banks to manage CBDC.** As discussed earlier, banks could offer wallets to hold and make transactions in CBDC and could offer customer support.

Scenario 2: Run Risk in Times of Systemic Financial Stress

48. **CBDC may facilitate a generalized run on banks by offering a readily available, safe, and liquid alternative to deposits.³³ But in many cases, this effect will be muted.** First, the introduction of CBDC would not facilitate idiosyncratic runs from one bank to another. Such movement can already take place electronically at the click of a button. Second, if a banking crisis coincides with a more general economic (currency or sovereign) crisis, funds will be withdrawn from all local assets, including CBDC.³⁴ Third, even short of a general crisis, CBDC is unlikely to matter much if very safe and liquid alternatives already exist. These include reserves-only narrow banks or Treasury-only mutual funds³⁵ or, in some cases, state banks with healthy balance sheets or explicit and credible state guarantees.³⁶

49. **In some cases, CBDC could even help the central bank ease liquidity pressures and thus contain bank runs.³⁷** The provision of extensive liquidity support is pervasive during banking crises. For example, central banks provided liquidity assistance to banks in almost 96 percent of the 151 crisis episodes studied by Laeven and Valencia (2018). Liquidity can be provided by increasing

³² A situation in which the central bank does not recycle deposits back to banks, but instead takes on the direct role of maturity transformation and intermediation, would mean an even larger departure from the central bank mandate and could give rise to a sovereign–central bank nexus, if the monetary authority is pressured to lend to the government.

³³ Bank run models, such as Diamond and Dybvig (1983) and Goldstein and Pauzner (2005) and references therein, emphasize information asymmetries regarding liquidity mismatches on banks' balance sheets, and liquidity needs of depositors, as the driving forces behind runs. Depositors may also run because of concerns about solvency rather than illiquidity (Calomiris and Gorton 1991).

³⁴ In more general economic crises, depositors may also fear losses in real terms because of high inflation and currency depreciation and may thus attempt to hold foreign assets, leading to capital outflows. In fact, almost 30 percent of banking crises coincide with currency and/or sovereign crises (Laeven and Valencia 2018). Emerging market and developing economies are more susceptible to these twin or triple crises (Caprio and Klingebiel 1996; Laeven and Valencia 2018). Advanced economies are not immune to these episodes as is evident in the recent European sovereign debt crisis (IMF 2011; Brown, Evangelou, and Stix 2017; Sibert 2013).

³⁵ Schmidt, Timmermann, and Wermers (2016) document runs from money market mutual funds following the collapse of Lehman Brothers in 2008, showing that while most prime money market mutual funds experienced outflows, those invested in Treasury bills observed strong inflows "as investors sought the liquidity of the U.S. government market as part of a flight-to-safety."

³⁶ Barajas and Steiner (2000), focusing on depositor behavior in Colombia, and Mondschean and Opiela (1999), considering Poland, find that state banks are perceived as safer and have an advantage in attracting deposits relative to private banks. However, a large number of studies, focusing on a diverse set of countries, do not offer corroborating evidence (Adler and Cerutti 2015; Hasan, Jackowicz, Kowalewski, and Kozlowski. 2013; Semenova 2007; Das and Ghosh 2004; Ungan and Caner 2004; Hori, Ito, and Murata 2009).

³⁷ The absence of a lender of last resort has been associated with US banking panics in the pre–Federal Reserve era (Calomiris 2008; Gorton and Tallman 2016).

reserves (to replace funding) and cash (to allow banks to meet deposit withdrawals). Having CBDC will not affect the central bank's ability to increase reserves, since this can already take place electronically. But in geographically vast countries where transporting cash to bank branches and ATMs might be a costly and time-consuming endeavor, CBDC could also facilitate the process of providing liquidity to banks and resolve runs faster.³⁸

50. **Even if the introduction of CBDC increased the risk of systemic bank runs, deposit insurance could alleviate the effects.** Liquidity provision needs are smaller in countries with deposit insurance before a banking crisis.³⁹ Countries adopting CBDC should, therefore, have a deposit insurance scheme to lower the probability of runs.⁴⁰ The effectiveness of such schemes in mitigating runs, though, will depend on the credibility of the fiscal backstop and the extent of coverage.

Would Monetary Policy Transmission Remain Effective?

51. **The introduction of CBDC is unlikely to significantly affect the main channels of monetary policy transmission under plausible CBDC designs.**⁴¹ The channels are fourfold:

- The basic *interest rate channel* may be the most affected and could strengthen. Changes in policy interest rates induce households and firms to rebalance investment and consumption between the future and the present, especially if these are exposed to interest-sensitive borrowing and saving instruments. To the extent that CBDC increases financial inclusion—thus access precisely to such instruments—monetary policy transmission could strengthen (Mehrotra and Nadhanael 2016). Gains would be most evident if CBDC were interest bearing.
- The *bank lending channel* could also strengthen. Through this channel, policy interest rates and their expectation affect bank balance sheets and profits—ultimately their creditworthiness and thus their nondeposit funding cost and lending rates.⁴² This channel would strengthen if CBDC increased the share of banks' wholesale funding, as argued earlier.

³⁸ For similar reasons, central banks should not impose aggregate limits on CBDC in circulation. These could induce price distortions as a result of scarcity premiums. These limits could also accelerate runs as there is an attempt to purchase CBDC before others do and the aggregate limit is reached. Note also that the trigger for a run could become more unpredictable; when the run is to CBDC rather than to cash it will be harder for depositors to observe the signal of others' liquidity needs or information about the bank as there will be no lining up outside branches.

³⁹ In the Laeven and Valencia (2018) sample of crises, median peak liquidity provision was 15.3 percent in countries with deposit insurance; it was 22.4 percent of deposits for countries without it. In addition, there is evidence that uninsured wholesale depositors are more predisposed to runs (Covitz, Liang, and Suarez 2013).

⁴⁰ In fact, some runs, such as the case of the run on Northern Rock in the United Kingdom in 2007, have been associated with gaps in deposit insurance coverage for small depositors (Goodhart 2011).

⁴¹ Similar conclusions are suggested in Meaning and others (2018) and in CPMI (2018). Another unexplored, though interesting, channel is the potential for CBDC to facilitate the resetting of prices and thus weaken transmission. A more remote option requiring attention is for CBDC to allow for interest rates to differ across individuals or regions.

⁴² See Bernanke (2007) and references therein for a full description of the bank lending channel. Older versions of this channel, originating in a period with higher reserve requirements and credit market segmentation, suggested that a higher supply of reserves increased deposits—loanable funds—and hence bank lending.

- The *credit channel* is unlikely to be affected much. This channel is related to the one above; policy rates affect asset prices and collateral values of borrowers, thus their creditworthiness and costs of borrowing.⁴³ However, CBDC should not markedly impinge on these effects.
- Likewise, the *exchange rate channel*—through which changes in policy rates bring about rebalancing between foreign and domestic assets, and a commensurate variation in the exchange rate affecting exports and imports—is unlikely to be affected.

52. **This relatively benign view depends on the expectation that central banks would remain in a position to affect market interest rates relevant to the channels above.** First, central banks should be able to affect term spreads through communication as before, such as by releasing and discussing their interest rate projections. Second, central banks should be able to retain control of interest rates on reserves. As long as banks demand reserve balances to pay each other—ultimately, as long as banks intermediate payments—the central bank should be able to set their marginal price.⁴⁴ This is key, since the price of reserves determines the opportunity cost for banks to lend funds to each other, and by extension the rates set in the much larger money markets. In turn, these affect rates on riskless, and ultimately risky, assets. Clearly, the presence of banks across these markets, as well as arbitrage and lack of market segmentation, is key to transmission. CBDC, however, is not expected to markedly affect any of these conditions under most design scenarios.

53. **One scenario, however, would significantly test the standard transmission channels, but could be resolved with a change in operating framework.** If banks were no longer involved in intermediating payments, having lost the business to CBDC (or stored value facilities, depending on how these are regulated), demand for reserves would disappear. This scenario resembles the “cashless world” considered by Woodford (2000). In this world, though, monetary policy has the means to remain effective. Woodford argues that “perfect control over overnight rates would still be possible, through adjustments of the rate paid on central bank balances.” In the digital world, the insight translates into paying interest on CBDC. Doing so would put a floor on interest rates if CBDC is provided without limit. Indeed, no one with access to CBDC would lend at a rate below that offered by CBDC, which would remain the safest and most liquid asset available. This is akin to controlling monetary policy by paying interest on reserves when these are in excess of what is demanded by the banking sector for precautionary purposes (referred to as a “floor system”).

⁴³ It could weaken if fintech innovations, beyond just CBDC, reduce information asymmetries inherent in the markups charged to borrowers.

⁴⁴ Some adjustments may nevertheless be necessary to central banks’ operating frameworks. CBDC is likely to displace cash, but could also partially drain reserves from commercial banks if customers withdraw deposits to hold CBDC. To the extent that banks need the reserves for precautionary purposes, central banks would still be able to replenish these by engaging in liquidity-injecting open market operations. Ultimately, demand for precautionary reserves might actually decrease, because CBDC could attenuate the variance of payment shocks (unlike cash, CBDC does not require lumpy withdrawals from costly visits to ATMs) or increase their predictability. But even if the shape and position of the demand curve for reserves change, central banks should be able to adapt their supply of reserves to stabilize interest rates. In the interim, movements between deposits and CBDC could be volatile and require more frequent liquidity-injecting open market operations—perhaps on a fixed-rate full allotment basis—to stabilize interest rates. A floor system could also be considered to stabilize interest rates, since the demand for liquidity does not need to be accurately forecast.

VI. CENTRAL BANK RESEARCH AND EXPERIMENTS

54. **Several central banks, in both advanced and emerging market and developing economies, are considering the pros and cons of issuing CBDC.** Table 1 summarizes the jurisdictions in which central banks are (or have been) actively exploring CBDC for retail use based on publicly available information.

Table 1. Jurisdictions Where Retail CBDCs Are Being Actively Explored ^{45,46}	
Australia (on hold)	Bahamas
Brazil	Canada
China (and here)	Curaçao and Sint Maarten
Eastern Caribbean	Ecuador (pilot complete)
Denmark (rejected)	Israel
Norway (ongoing)	Philippines
Sweden	United Kingdom (on hold)
Uruguay (and here) (pilot)	
Sources: Central banks or various news sources per hyperlinks above. (Information has not been verified through official channels.)	

55. **Some sovereigns have issued, or may issue, retail digital currencies, though these are not CBDC because they are not issued by central banks as their liability.** For example, the [Marshall Islands has discussed launching the SOV](#), a crypto asset that will become legal tender along with the US dollar, with the apparent intention to raise funds for the government. Likewise, Venezuela is planning to issue the [petro, a commodity-backed crypto asset](#).

56. **Central banks are considering CBDC for two main reasons: Declining use of cash in advanced economies and financial inclusion in emerging market and developing economies.** These and other objectives mentioned by central banks are summarized in Table 2. None of the central banks surveyed cite seigniorage preservation or monetary policy effectiveness at the zero

⁴⁵ “Active” means central banks that have convened projects to seriously explore CBDC or that have undertaken pilots. Some central banks have publicly indicated that they are investigating CBDC but have provided little to no detail. These include central banks in [Bahrain](#), [Barbados](#), [Egypt](#), the [Euro Area](#) (and [rejected](#)), [Hong Kong SAR](#), [India](#), [Indonesia](#), [Israel](#), [Jamaica](#), [Korea](#) (and [rejected](#)), [Lebanon](#), [New Zealand](#) (on hold), [Russia](#), and [Switzerland](#).

⁴⁶ There is doubt about Senegal’s and Tunisia’s CBDC, which appear to be [fiat-collateralized crypto assets](#). In the case of Senegal’s e-CFA e-currency, the only connection to the central bank seems to be that the e-currency complies with the e-money regulations of the [Banque Centrale des Etats de l’Afrique de l’Ouest](#). In Tunisia, the [post office](#) has been operating an e-dinar digital money wallet since 2000, and in 2016 it partnered with [Monetas](#) and [DigitUs](#) to offer a crypto-powered payment app, but there has been no central bank involvement.

lower bound as rationales for CBDC adoption, with papers by the Bank of Canada emphatically denying the latter.⁴⁷ The main rationale for advanced economies seems to be countering the growth of private forms of money (operational risk and monopoly distortions) and reducing costs associated with managing cash (cost efficiency). For example, Sweden points to increasing [payment system single-point-of-failure risk](#) associated with diminishing cash usage. In emerging market economies, the main interest in CBDC seems to be fostering financial inclusion by reaching out to the unbanked segments of the population. Only China cites monopoly distortions as a justification. Cost efficiency is also behind China's investigations, Ecuador's CBDC issuance (launched in early 2015 though shut down in early 2018), and Uruguay's six-month trial.⁴⁸ Some developing economy central banks have also mentioned reducing the costs and risks associated with the distribution of physical cash.

Table 2. Rationales for Exploring CBDCs via Publicly Available Information					
	Diminishing Cash Usage				
	Monopoly Distortions	Operational Risks	Cost Efficiency	Financial Inclusion	Other
Bahamas				X	Countering derisking
Canada	X				
China	X	X	X	X	
CBCS		X	X	X	
ECCB		X	X	X	
Ecuador			X		
Norway	X				
Senegal				X	
Sweden	X	X			
Tunisia				X	
Uruguay			X	X	
Monetary policy was not cited as a rationale by any of the central banks surveyed. It was not possible to ascertain the rationales, based on publicly available information, for Australia, Bahrain, Denmark, the European Union, Hong Kong SAR, India, Indonesia, Jamaica, South Korea, and Switzerland.					
Sources: Central banks or various news sources (as indicated in italics) per hyperlinks in Table 1. Information has not been verified through official channels.					
Note: CBCS = Central Bank of Curaçao and Sint Maarten; ECCB = Eastern Caribbean Central Bank.					

⁴⁷ Engert and Fung (2017) conclude that "reducing the effective lower bound does not provide a compelling motivation to issue CBDC."

⁴⁸ Ecuador's main rationale was to avoid the costs of managing physical dollars in its fully dollarized economy. However, user acceptance was very low, seemingly because of lack of trust in the central bank (White 2018).

57. **Some central banks are reportedly no longer pursuing CBDC.** Factors cited include small benefits for central banks and potential disintermediation and bank run risks (Australia, Denmark, European Central Bank, New Zealand, Switzerland).

58. **In terms of design, most central banks seem to be contemplating forms of account-based CBDC, though with various levels of anonymity; some token-based solutions also exist.** The Eastern Caribbean Central Bank and the People's Bank of China could offer both account- and token-based CBDC, with accounts managed by commercial banks and/or other licensed financial institutions. The People's Bank of China is also considering fully anonymous token-based wallets, albeit with low payment limits. However, other central banks seem to be shying away from such solutions because they would not meet Financial Action Task Force requirements.⁴⁹ Most central banks are considering anonymous CBDC when it comes to transacting parties and third parties but not in the case of the government. This is the situation of the People's Bank of China. (Wallets with greater anonymity, however, would have lower payment limits.) Protecting users against risks of theft and loss was considered important to many of the central banks mentioned.

59. **A number of central banks surveyed indicated that CBDC should be available 24 hours a day, 7 days a week, to mimic the accessibility of cash.** In this regard, Canada, China, and Sweden are looking into CBDC with offline capability. This would be offered by preloading tokens onto a wallet while online, then validating transactions via encrypted messaging to point-of-sale terminals, similarly to cash cards. In all cases, central banks are considering limits to such transactions. Functionality could be temporarily available during electricity or infrastructure breakdowns but still be susceptible to catastrophic events.⁵⁰ Even cash is not particularly resilient in such circumstances, as its distribution and use require electricity (to operate automated teller machines, vending machines, and other cash dispensers), and cash can be destroyed easily in a catastrophe.

60. **None of the central banks surveyed are seriously considering interest-bearing CBDC.** Central banks appear to be concerned with financial intermediation, lending contraction, and heightened bank balance sheet volatility. Some, such as the [Reserve Bank of New Zealand](#) and Uruguay simply assert on principle that CBDC should be fungible. Central banks contemplating token-based CBDC suggest that paying interest would present a technical challenge, though not an insurmountable one. Others raise the hurdle of tracking interest payments for tax purposes. However, Sweden's proposed CBDC, the e-krona, will have the built-in ability to pay interest if the central bank decides to do so.

61. **The central banks surveyed are studying ways of managing and funding CBDC infrastructure.** Although marginal costs of managing physical cash are likely higher than those of

⁴⁹ The [Financial Action Task Force](#) is an independent intergovernmental body that develops and promotes policies to protect the global financial system against money laundering, terrorism financing, and the financing of proliferation of weapons of mass destruction. It has set out recommendations for customer due diligence (for instance, identity verification) implementation, record keeping, and suspicious transaction reporting requirements for financial institutions and designated nonfinancial businesses and professions.

⁵⁰ A recurrence of the 1859 [Carrington Event](#) could knock out communications and power for up to a year and render digital money useless.

CBDC, the high up-front fixed costs may favor CBDC adoption in larger economies. Some central banks are exploring the option of building and maintaining CBDC in-house, but most are planning to outsource these onerous tasks, despite the risks involved. Some central banks are contemplating cost-sharing mechanisms. For example, China may make third-party wallet providers bear part of the development costs in return for keeping a cut of any fees charged and benefiting from cross-selling opportunities. The Uruguay pilot appears similar. China is also thinking about charging fees on large transactions, just as for large cash withdrawals.

62. **Various central banks surveyed plan to outsource CBDC development, though under close supervision.** For example, the Uruguay CBDC pilot turned to the [Roberto Giori Company](#) to develop digital notes, [IN Switch Solutions](#) for wallets, and [Redpagos](#) for “storefront” operations (cashing e-pesos in and out). Tunisia used [Monetas](#) for digital notes and [DigitUS](#) for wallets, but developed the user interface itself (according to [The Tunisian Post](#)). Senegal used [eCurrency Mint](#) for the notes, while the [Banque Régionale de Marchés](#) provided the wallets and user interface.⁵¹

63. **Central banks are for the most part focused on CBDC applications for the domestic economy.** Only Canada and China mentioned cross-border issues, but more as complications than opportunities. Canada seemed focused on accessibility by tourists. China cited cross-border capital management. Other projects focus more on intermediating wholesale payments across borders, such as a joint project between the Bank of Canada, the Monetary Authority of Singapore, and the Bank of England.

VII. CONCLUSION

64. **CBDC could be the next milestone in the evolution of money.** The history of money suggests that, while the basic functions of money might not change, the form does evolve in response to user needs. Digitalization of many aspects of economic activity is prompting central banks to seriously consider the introduction of CBDC.

65. **CBDC is a digital form of existing fiat money, issued by the central bank and intended as legal tender.** It would potentially be available for all types of payments and could be implemented with a variety of technologies.

66. **This discussion note introduces a three-step conceptual framework to assess CBDC’s potential to create value both for end users and for central banks.** The first step is to identify the criteria with which users evaluate different forms of money. The second step involves establishing the public policy goals of central banks with respect to money. The third step lays out the competitive landscape, comprising existing and evolving forms of money.

67. **Overall, the note finds no universal case for CBDC adoption as yet. From the perspective of end user needs, it finds that demand for CBDC will depend on the attractiveness of alternative forms of money.** In advanced economies, there may be scope for the adoption of CBDC as a potential replacement for cash for small-value, pseudo-anonymous

⁵¹ The International Telecommunications Union is working on standardized terms and conditions for the design of digital fiat currencies, including currencies issued by central banks and managed by private entities.

transactions. But in countries with limited banking sector penetration and inefficient settlement technology, demand for CBDC may well be greater.

68. **From a central bank perspective, the case for CBDC is likely to differ from country to country.** CBDC may reduce the costs to society that are associated with the use of cash. Moreover, CBDC may improve financial inclusion in cases of unsuccessful private sector solutions and policy efforts. It could also help central banks bolster the security of, and trust in, the payment system and protect consumers where regulation does not adequately contain private monopolies. But regulation and, where possible, novel payment solutions could offer compelling alternatives to a CBDC.

69. **For countries that decide to introduce CBDC, appropriate design and policies should help mitigate ensuing risks.** Monetary policy transmission is unlikely to be significantly affected and may even benefit from greater financial inclusion. Moreover, though it will not eliminate illicit activity, CBDC may in some situations enhance financial integrity. However, it also entails risks for financial integrity if badly designed. In addition, although CBDC could increase the cost of funding for deposit-taking institutions and intensify run risk in some jurisdictions, design choices and policies can help ease such concerns. Nevertheless, operational and reputational risks arising from malfunctions of the digital infrastructure or cyberattacks are likely to remain as challenges.

70. **Looking ahead, the cross-border implications of CBDC raise a multitude of new questions that merit investigation.** For instance, from a practical standpoint, how would tourists be able to make payments in a foreign country that has adopted CBDC? Should foreigners have access to CBDC? To what extent would this complicate know-your-customer and AML/CFT compliance, and could standardized information be requested across countries? Would access to CBDC in a reserve currency (such as e-dollars) facilitate currency substitution in countries that have weak institutions? And to what extent might safe-haven flows be encouraged, potentially draining resources from countries that face banking, sovereign, or currency crises? Finally, if CBDC were used for cross-border transactions, how might central banks be required to cooperate? Would they absorb some of the functions of correspondent banks and thus take on additional liquidity, credit, and foreign exchange rate risk—or might tokens be created for cross-border payments among particular central banks, commercial banks, or firms? Research on CBDC should proceed resolutely given that the questions to be explored are deep and difficult and have far-reaching implications.

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APPENDIX

Figure A1.1. Attractiveness to Users of Different Forms of Money

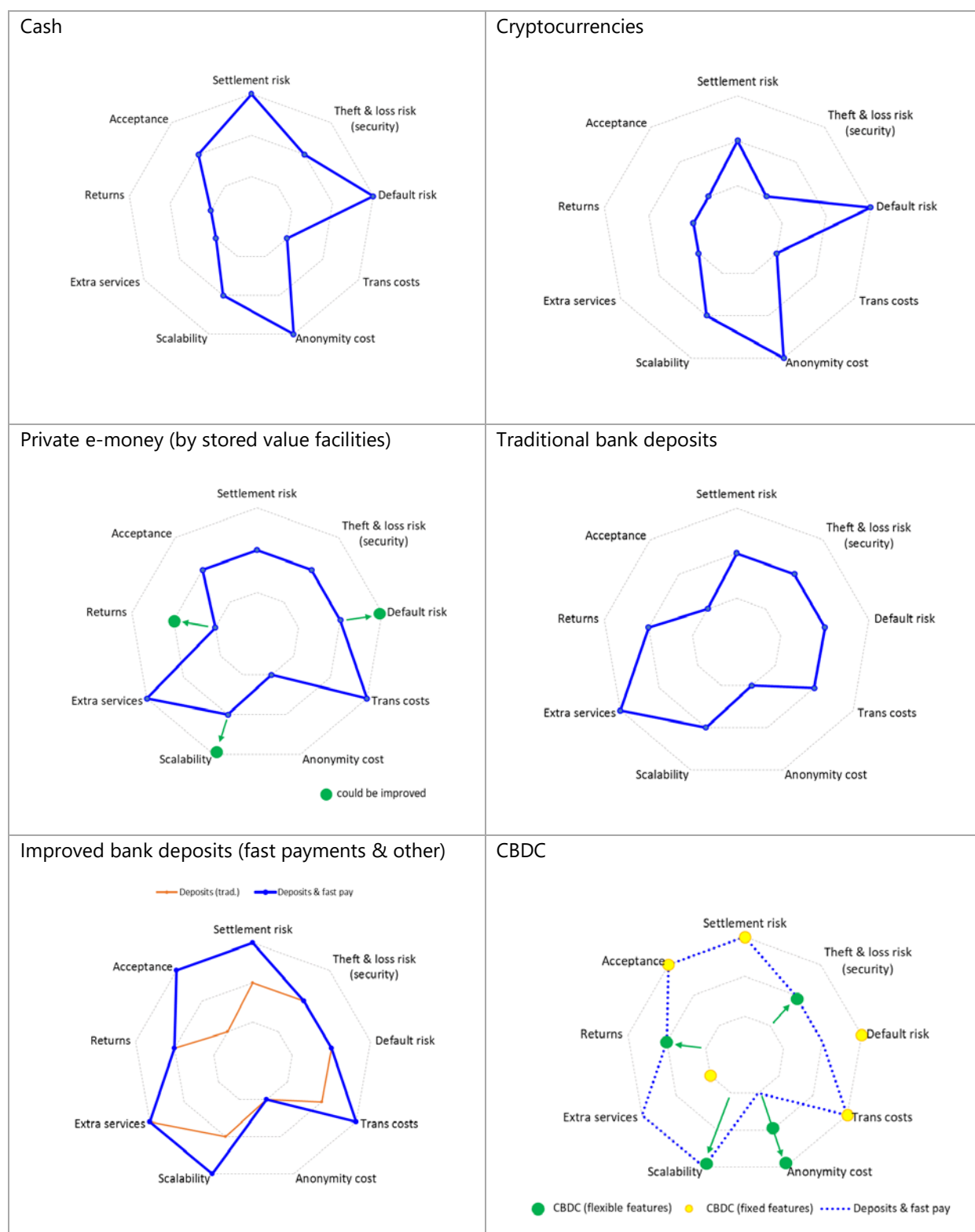


Table A1.1. Scores by Criteria

	Cash	Traditional bank deposits	Cryptocurrencies*	Private e-money (by stored value facilities)	Bank deposits with fast payment
Scalability	M: not for large-value transactions	M: not for small- or micro-value transactions	L: not for large payments	M: could be expanded to large-value transactions	H: all transactions possible
Extra services	L: none	H: access to all bank services	L: limited services through exchanges	H: integration with social and financial services	H: like bank deposits
Interest returns	L: zero yielding	M: interest, though below policy rate	L: none	L: usually none, though could be offered	M: interest
Acceptance	M: limits to change; some merchants reject	L: only person to business and business to business, point-of-sale terminals needed	L: only few retailers accept	M: person to business, business to business, person to person, but only within network	H: like stored value facilities but no network limit
Settlement risk	H: none; immediate settlement	M: some delay	M: lags; struggle to establish finality for some	M: like bank deposits	H: instantaneous in central bank money (reserves)
Theft & loss risk	M: hard to recover/claim; no cyber risk	M: can reverse transaction & claim ownership	L: hard to recover/claim due to anonymity	M: like bank deposits	M: like bank deposits
Default risk	H: none, a central bank liability	M: deposit insurance	H: to the extent code is solid, not a liability	M: no deposit insurance, though some safeguards	M: like bank deposits
Transaction costs	L: need to physically meet	M: service fees	L: high energy requirements	H: very easy to use, cheap	H: very easy to use, cheap
Anonymity costs	H: full anonymity	L: not anonymous	H: full anonymity	L: not anonymous	L: not anonymous

Note: Scores are H (high), M (medium), and L (low) to the extent the corresponding criteria are desirable for the end user. For instance, a high mark for transaction costs means that costs are low and thus attractive to users. *Rapidly evolving technological advances could improve scores.