WE ARE NOT IN KANSAS ANYMORE: KEY DRIVERS, POLICY QUESTIONS AND DESIGN CONSIDERATIONS FOR RETAIL CENTRAL BANK DIGITAL CURRENCIES

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Abstract

The central bank of the future needs a monetary instrument for the digital age, alongside notes and coins. This paper focuses on the motivations, policy questions, and design issues for a retail central bank digital currency (CBDC) in a rapidly-digitalizing world. The attraction of CBDCs for developing countries stems from efficiency gains, expanded markets and financial inclusion. Ensuring that the general public has access to a well-regulated and state-guaranteed digital means of payment, which enhances financial stability, is also an important benefit. Meanwhile, advanced economies have a need for continued public access to central bank money, given economies of scale and network externalities. The COVID-19 pandemic has accelerated the decline in cash use and has also highlighted the need for a digital instrument that governments can use for efficiently distributing financial aid instantaneously. With regard to policy concerns about reduced credit intermediation and precipitating bank runs, we argue that these concerns should not be overstated. Moreover, CBDCs may actually help achieve a more stable structure of the financial system by further separating credit provision from payment systems. Finally, we consider the design of CBDCs and propose an architecture along with policy and operational requirements to get the full benefit for an economy, while recognizing the tradeoffs involved. The design attributes also need to be geared towards enhancing the attractiveness of CBDC for retail users.

Keywords: CBDC, Central Bank, COVID-19, Credit Intermediation, Digital Currency, Financial Inclusion, Financial Stability, Money, Payment Service Provider

I. Introduction

Digital innovations are causing a rethink of monetary arrangements and payment systems. In particular, the question whether central banks should issue digital currency for retail use is attracting considerable debate.[1] It is a pressing question in many developing countries, where a retail central bank digital currency (CBDC), a liability of the central bank for use by the general public, could not only catalyze growth-enhancing and inequality-reducing financial inclusion, but also spur efficiency gains in part from reduced cash use, which tends to be high.

Meanwhile, the question is also pressing in many advanced countries, such as Sweden, where cash is rapidly disappearing from circulation, and payments are almost exclusively done using privately-issued bank money. As a result, the Swedish Riksbank could soon face a situation where people would not have access to a government-issued and -backed medium of exchange (Sveriges Riksbank, 2018).[2] Other countries, such as Canada, are also preparing for such a contingency (Bank of Canada, 2020).

From a welfare point of view, an argument could surely be made that consumers should not be deprived of access to a safe and trusted medium of exchange, which is a liability of the central bank. Moreover, it is conceivable that trust in bank money might become more fragile if depositors don't have the option to convert deposits into central bank money. In the absence of cash, the payment system would likely be dominated by a few large--potentially foreign—private payment service providers (PSPs) as a result of network externalities, which raises concerns of competition, consumer protection, and efficiency along with financial stability if they were to fail.[3]

The insolvency in June 2020 of Europe's leading payment company, Wirecard, highlighted financial stability concerns from the use of private money and also exposed the shortcomings of a fragmented regulatory system.[4] As such, to provide people and businesses direct access to central bank money free of counterparty risk and obtain efficiency and other gains, central banks in both mature and developing countries are considering launching CBDCs for retail use.[5]

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[1] While CBDC can also be developed for national wholesale transactions, and both retail and wholesale CBDCs can be used for cross-border payments, the primary focus of central banks is increasingly on retail CBDCs for domestic use.

[2] This prompted the Riksbank to launch the retail e-krona proof-of-concept in early 2020.

[3] The challenge from private non-bank money (e-money, cryptocurrencies and stablecoins) is pushing central banks to innovate, and Facebook's Libra initiative, announced in June 2019, may have been a tipping point.

[4] "What the Wirecard story highlights is that as finance evolves away from a bank-centric model towards fintech and shadow banks, watchdogs need to switch to system-wide supervision" (The Financial Times, Editorial, July 19, 2020).

[5] According to the BIS (2020), "central bank digital currencies (CBDCs) can foster competition among private sector intermediaries, set high standards for safety and risk management, and serve as a basis for sound innovation in payments."

Many analysts argue, however, that direct access to central bank money could have adverse consequences for the economy and for financial stability. Critics claim that the introduction of CBDC would most likely lead to a reduction in credit intermediation as a result of an outflow of bank deposits into CBDC accounts or wallets. At the same time, if banks have to compete particularly with interest-paying CBDCs, banks' funding costs would rise, pushing up their lending rates and/or squeezing margins. Many observers also fear that by providing an easy way to convert bank deposits into a safe government-backed asset, CBDCs could destabilize the financial system during crises by facilitating and accelerating system-wide retail bank runs, which could substantially undermine financial stability.

We take issue with both assertions and will argue that the concerns about reduced financial intermediation and heightened financial instability are vastly overstated. Our counterargument to the worries about declining credit intermediation is largely based on the observation that banks do not necessarily need deposits (or funding more generally) to provide lending to the economy. What banks need are central bank reserves (and capital to satisfy regulatory requirements). Moreover, the volume of demand deposits – the type of deposits most susceptible to conversion to CBDC wallets – appears manageable in advanced countries. For example, demand deposits in the U.S. amounted to only about 2 percent of the total credit volume in 2019.

In addition, there has been a secular trend towards more lending by non-bank financial institutions (which, unlike banks, cannot create money and thus *intermediate* their funding into loans) and a correspondingly diminished role for banks, particularly in the United States. If CBDC skeptics were correct, this trend would have significantly curtailed the availability of credit in the economy—which obviously has not been the case.

Similarly, the claim of an increased bank-run risk with CBDCs is overstated. Even today, retail depositors have various ways to pull deposits out of the banking system fast online, e.g. by investing into money market funds that invest exclusively into government securities or by putting money directly into U.S. T-bills through TreasuryDirect. In fact, by facilitating shifting into a government-issued store of value and medium of exchange, CBDCs could conceivably exert positive disciplining effects on banks' lending and risk-taking behaviors and could set in motion a further decoupling of the credit process from money creation and payment systems, with welcome stabilizing effects on the structure of the financial system.

We also analyze the design consideration for CBDCs, which are important not only to central banks but also to actual users. A badly designed CBDC may not yield all the hoped-for gains from its introduction. Equally, it could exacerbate risk concerns. Moreover, an unattractive CBDC design may hamper their take-up and use by retail consumers. As such, we argue that the design of CBDC holds the key for its success and propose one such architecture, which is applicable to both developing and advanced economies. More concretely, we have a two-tiered CBDC architecture in mind, the *hybrid* model, where the central bank issues CBDC, a cash-like

digital bearer instrument, which is distributed by private payment service providers (PSPs) for use by consumers and small businesses for high-volume low-value retail transactions.

The paper is organized as follows. We confine our study to CBDCs for domestic retail use, discussing in Section II the key drivers for CBDCs in both advanced and developing economies. We turn to policy questions next, analyzing in Section III the possible negative impact of CBDCs on credit intermediation, if any, before evaluating in Section IV whether CBDCs could worsen the threat of bank runs or conversely make the financial system less fragile. In Section V, we turn to design considerations for a successful CBDC, focusing on architecture, policy and operational requirements, before we discuss, in Section VI, technology selection. Section VII concludes.

II. What are the primary drivers for introducing retail CBDCs?

In advanced economies, where cash-use has already declined dramatically or its fall is only a matter of time, an argument could surely be made that consumers should not be deprived of access to a safe and trusted medium of exchange.[6,7] In the absence of CBDC, the payment system would likely also be dominated by a few large private providers, raising competition concerns, since they are natural monopolies due to economies of scale, network externalities, and centralized settlement. Hence, it is important to preserve the current choice and strategic complementarity between central bank money (such as cash) and bank money through the introduction of a CBDC for retail use. Otherwise, society could be pushed into a vicious welfare-reducing cycle, with households using less and less cash, retailers not accepting cash payments, and banks not providing the cash-in and -out facilities. Another powerful motivator is alleviating financial stability concerns, which were highlighted by the Wirecard insolvency in Germany. These arise because the money used by PSPs is their own and not central bank liabilities, and concerns would be exacerbated by the failure of such systemically large institutions.[8]

Meanwhile, developing countries may have similar concerns, including possible private sector monopolies in payment systems and rapidly expanding non-bank PSPs.[9] But in their context even more powerful drivers of the need for CBDCs exist.[10] Ensuring that the general public has

[6] Bank of Canada (2020) and Bindseil (2020) discuss some of the reasons for advanced economies to adopt retail CBDCs, including payments efficiency, safety, and curbing illicit activities.
[7] Auer et. al. (2020a) provides evidence of how the COVID-19 pandemic is accelerating digitalization and reducing cash use due to social distancing and concerns about handling virus-tainted currency.
[8] As Kiff et. al. (2020) make clear in their money matrix, the money flowing through PSPs are not central bank liabilities, and may or may not be backed by reserves with the monetary authorities.
[9] With the dominance of Alipay and WeChat Pay in retail payments in China, ensuring competition in payment systems and financial stability are key reasons that prompted the People's Bank of China (PBC) to launch a retail CBDC pilot in early 2020, the first large country to do so.
[10] Boar et. al. (2020) reports that 80% of the 66 central banks surveyed by the BIS are engaged in CBDC work, with those representing a fifth of the world's population indicating that they are likely to issue CBDCs soon and that developing countries having stronger motivations than advanced economies.

access to a well-regulated and state-guaranteed digital means of payment could spur rapid expansion of e-wallets and other services. In situations where typically half the population in developing countries is unbanked, CBDC would promote financial inclusion by making the payment network interoperable across all PSPs.[11] Benefits would derive from expanded reach of markets and commerce, especially for small businesses, as CBDCs are not limited by the denomination structure of banknotes and, unlike cash, can be used for long-distance transactions. As high cash usage declines in developing countries, efficiency gains would also arise from lower transaction costs, along with reduced expenses for printing and distributing money. The total annual societal cost of cash could be 1-2% of GDP, or up to 5% of the value of transactions (McKinsey, 2013).

Thus, through CBDCs, central banks could have a significant positive economic and social impact. In its *Global Findex Report,* the World Bank (2018) estimates that 1.7 billion people world-wide were unbanked, primarily in developing countries. The spread of formal banking services has been constrained by the high cost of physically reaching people in remote and rural areas, and by the economics of servicing low-income populations, informal sectors and small- and medium-sized enterprises (SMEs). CBDC has the potential to remove these constraints while providing cheaper and faster services, powering e-commerce, and being a catalyst for the expansion of fintech.

Another motivation for CBDCs could arise in both developing and advanced economies, if governments want a vehicle for social programs to disburse money to citizens instantaneously and at low cost. For example, retail CBDCs would have come in very handy during the COVID-19 pandemic, facilitating the quick disbursement of emergency funds to households, akin to the use of helicopter money. Moreover, to address concerns about the virus possibly tainting physical currency, people could use CBDC as an alternative payment instrument.

In sum, the arguments above would support introducing a retail CBDC that replicates the positive features of cash in a digital form, while maintaining the functionalities of cash. Central banks would control issuance and distribution of CBDCs, alongside notes and coins, while private e-money operators and other payment service providers would handle the consumer-facing aspects. CBDCs, supported by an appropriate regulatory architecture, could thus allay associated risks, including payment systems stability, competition, consumer and investor protection, data privacy, cyber security, money laundering, and terrorism financing. While the development of faster, cheaper, and more efficient and reliable Real Time Gross Settlement (RTGS) systems would be important for wholesale transactions, there would still be a need for retail CBDCs in advanced economies, and, even more so in developing countries, with their huge scope for financial inclusion and large reliance on cash.

III. Would CBDCs reduce credit intermediation?

Many analysts and observers claim that the introduction of CBDCs would most likely lead to a considerable reduction in credit intermediation and higher lending rates as a result of an

[11] See Barr et. al. (2020) for a detailed discussion on how central banks can improve financial inclusion.

outflow of bank deposits into CBDC accounts or wallets.[12] As consumers shift funds from their demand deposits into their CBDC wallets, banks would lose funding and reserves—similar to depositors withdrawing cash from their bank accounts. As a result, bank balance sheets would shrink as a reflection of disintermediation. Banks could react to this outflow in various ways. They could resort to attracting other types of funding. Alternatively, banks might be tempted to increase the interest offered on demand deposits to stem the outflow. In either case, the higher funding costs would probably be passed through into higher bank lending rates.[13]

But this concern is overstated since bank deposits or other types of funding are not necessary for bank lending because banks create money in the lending process. Banks only need central bank reserves to finance potential money outflows to other banks. In economics, banking is generally modelled in such a way that bank loans cannot be made unless someone saves economic resources and deposits them in a bank. But this view—sometimes referred to as the loanable funds approach—is largely an incorrect description of credit intermediation in the banking system, though it is correct for the intermediation by non-banks. [14] Because banks' deposit liabilities are accepted as media of exchange in the payment system, banks—unlike other private economic agents—can create "money." When a bank makes a loan, it simply credits the loan amount to the borrower's account. Thus, banks can expand their balance sheets with the "stroke of the pen" (by computer entry); bank funding is not required.[15]

If a bank makes a new loan, however, the bank needs to be prepared to have reserves (central bank money) on hand to fund a likely transfer of the newly created deposit to another bank.[16] Thus, the only potentially limiting factors for a bank's lending capacity are the banks' capital endowment (to satisfy regulatory capital requirements) and the reserves it holds at the central bank in order to settle interbank flows and cash outflows. In principle, therefore, banks can increase lending much in excess of their reserves holdings, while nonbanks can only lend out the central bank money that they receive from their funding sources. In other words, when a bank loses deposits as depositors transfer their funds to another bank, withdraw cash, or move funds into their CBDC wallets, the bank's lending capacity remains unchanged as long as it has enough (excess) central bank reserves to pay out the cash or finance the money transfers to other banks. Moreover, it could even be conceivable that greater financial inclusion catalyzed by CBDCs could, at the same time, result in additional deposit mobilization into the banking system.

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[12] For example, Broadbent (2016), Cecchetti and Schoenholtz (2017), and Mancini-Griffoli et al. (2018). For a balance-sheet analysis of disintermediation effects, see Bindseil (2020).

[13] For a detailed description, see Bank of England (2020).

[14] Jakab and Kumhof (2015).

[15] See Grasso and Siebenbrunner (2019) for a literature survey of monetary systems, who contrasts this money creation view of bank lending with the intermediation and fractional reserve approaches.

[16] This tends to be a larger problem for smaller banks (and more fragmented banking systems) because the likelihood that the money will be transferred is larger.

Two cases of bank deposit outflows to CBDC wallets have to be considered. In the first case, the bank's depositors shift some funds from their demand deposits into digital wallets that they hold at the very same bank. As a result, a certain amount of the bank's reserves at the central bank are swapped against an equal amount of the bank's CBDCs holdings at the central bank. In the other case, depositors shift funds into wallets that are held at specialized PSPs. In this case, the bank's reserves decline without an offsetting increase in CBDC holdings at the central bank.

The introduction of a CBDC will, ceteris paribus, thus reduce the reserves in the banking system, though the extent of the reduction is highly uncertain and depends on how retail depositors react, specifically how much of their deposits they convert into CBDC.[17] However, to the extent that banks hold excess reserves (whose volume currently is huge in many advanced countries), this outflow would not reduce the banks' capacity for money creation and, thus, their lending capacity. But even in a world without CBDCs, where digital payment services are offered exclusively by private PSPs, such as ApplePay, WeChat Pay, etc., the activities of these private payment service providers would also lead to "idle balances." Part of the transaction balances held by consumers at these payment providers are not available to be lent out by the banking system, particularly if digital balances have to be fully backed by central bank money as has been mandated in China since early 2019.

The exact potential extent of disintermediation will largely depend on the specific features of CBDCs, such as the degree of substitutability between CBDCs and demand deposits, particularly if CBDCs were interest bearing with significant interest rate differentials vis-a-vis deposits. But two considerations suggest that the consequences for credit intermediation that would be caused by reserve outflows into CBDCs should not be overstated.

First, the volume of demand deposits in the United States is comparatively small relative to GDP and relative to bank lending (Chart 1). Demand deposits (in percent of GDP) in fact declined steadily in recent decades to less than 3 percent of GDP just before the global financial crisis when bank lending was almost 30-times as large as demand deposit balances. After the crisis, demand deposit balances recovered as interest rates remained exceptionally low. Even in the current ultra-low interest environment in the wake of the pandemic, demand deposits at U.S.

[17] A number of recent theoretical papers have analyzed the effects of CBDCs on credit intermediation. Andolfatto (2018) demonstrates in a theoretical model with monopolistic banking competition that a CBDC does not necessarily lead to higher lending rates and reduced credit intermediation since banks' profit margins might get squeezed. Similarly, Chiu et al (2019) shows how a CBDC could be a boost to credit intermediation if the digital currency enhances competition in an oligopolistic banking system. In the model by Keister and Sanchez (2019), a central bank issued digital currency leads to a shift out of deposits and raises lending rates. Nonetheless, the digital currency promotes more efficient exchange, possibly leading to welfare gains. Agur et. al. (2019) construct a theoretical model to investigate the linkages between CBDC design features, bank credit intermediation, and demand for different types of money.

commercial banks surged to just over 10 percent of annual GDP in April 2020. Even if over time all demand deposits would be converted into CBDC, the bank "funding" loss—and thus the adverse effect on bank lending—would be considerably smaller than the volume of demand deposits suggests because, as explained above, what needs to be replaced are not the demand deposits per se but merely the reserves that underpinned the bank lending associated with the shifted demand deposits. That should be manageable, at least in the United States.

Second, the past few decades have witnessed a pronounced secular trend towards increased lending by non-banks and a correspondingly diminished role of commercial banks in the credit process, particularly in the United States. For example, in the United States, all the lending growth to non-financial businesses (in percent of GDP) since the early 1980s has been accounted for by non-bank lending (Chart 2). If we follow the logic of CBDC skeptics, this shift to non-bank lending, which presumably has been much larger than any potential future shift from bank deposits into CBDC wallets, would have substantially reduced the lending capacity in the economy because nonbanks cannot make loans by creating money. Non-banks, in effect, need funding of central bank money to fully back their lending—unlike banks, as we have discussed above. But the opposite appears to have happened: the lending capacity of the financial system surged.

Overall lending in the U.S. economy expanded over the past decades while the shift to non-bank lending was going on—in support of our hypothesis (Chart 3). Since 1980, total credit extension relative to GDP surged by 190 percentage points (more than doubling from 160 percent to 350 percent of GDP), while bank lending rose by 25 percentage points (from 40 percent of GDP to 65 percent of GDP). As a result, in 2019, less than 20% of total credit was accounted for by bank lending, and demand deposits were equivalent to merely 2 percent of overall credit volume in the economy.

Therefore, the central bank could relatively easily offset any reserve drain caused by the shift of deposits into CBDC wallets by providing new additional reserves to the banking system and thus keep banks' lending capacity broadly unchanged. Since bank loans do not need to be fully backed by central bank reserves, the injections would need to be just a small fraction of the targeted boost in bank lending. Moreover, central banks would not necessarily have to recycle the reserve drain associated with CBDCs directly to banks, as Niepelt (2020) and Brunnermeier and Niepelt (2019) claim.[18] Rather, much of the liquidity injections provided via central bank asset purchases, such as through quantitative easing, would ultimately lead to an increase in the banking system's reserves even though some of that liquidity might leak into CBDC wallets as transaction balances.

[18] Niepelt (2020) derives an equivalence proposition such that a substitution of CBDCs for bank deposits, together with appropriate fiscal transfers to the banking system, leaves macroeconomic outcomes unchanged at constant interest rates.

Finally, an argument could even be made that the current situation in most advanced countries, which is characterized by huge excessive bank reserves as a result of quantitative easing, might be a particularly propitious time to introduce CBDCs. To the extent that CBDCs would be accepted as a medium of exchange or store of value, they could be used to mop up some of the banks' excess reserves when the monetary policy stance shifts to a more neutral position, without any adverse effects on the banking system's lending capacity.

IV. Would CBDCs worsen the threat of bank runs? Or would CBDCs even make the financial system less fragile?

The concern that giving retail depositors a convenient tool to move money easily out of the banking system and into digital wallets could destabilize banks and accelerate bank runs should also not be overstated.[19] The trust that people have in their bank deposits is derived to a large extent from the protection offered by deposit insurance as well as financial regulation and supervision. This would continue to be the case in a CBDC world.

It is obviously true that unlimited CBDC wallets would provide retail depositors convenient ways to participate in a flight-to-safety by shifting bank deposits into e-cash. However, even today, retail depositors have several methods to quickly switch funds out of the banking system, e.g. into money market funds that invest exclusively in government securities or by investing directly in government bills (e.g. via TreasuryDirect in the U.S.). The marginal additional adverse effect on financial stability that may arise from this new CBDC channel for retail deposit outflows should be small. What is more, as history has demonstrated, the largest bank run threat typically stems from wholesale funding. This threat would not increase by the availability of CBDCs since institutional investors already have access to other safe-haven assets that dominate CBDCs in terms of rates of return.

From a society's welfare perspective, moreover, it is not clear why retail depositors should be prevented from having opportunities to convert their bank deposits into a safe central-bank-issued store of value and medium of exchange—even if the risk of bank runs might increase with CBDCs. The trust that depositors have in commercial-bank-issued money is to a large extent bolstered by depositors knowing that they have the option to convert their deposits into central bank issued cash—and, in future, into central-bank-issued digital currency.

In fact, the existence of digital currency could have some positive effects during a crisis. The central bank could rapidly transfer e-cash to banks that are confronted with a run by large numbers of depositors who are trying to shift their money into digital wallets. No lines of panicked depositors would form in front of banks, and thus further panic-inducing pictures in the media could be avoided. Episodes of bank ATMs running out of cash would become a historical curiosity.

[19] For a balance-sheet analysis of different bank run scenarios, see Bindseil (2020).

The fact that retail depositors would have access to CBDC may even have positive disciplining effects on banking. It could be argued that bank run threats could be considered an essential element in today's system that links money creation and credit: the possibility of bank runs provides some discipline on banks to hold sufficient reserves and to behave prudently in their lending and risk taking (e.g. Calomiris and Kahn, 1991). Additional *potential* fragility by introducing CBDCs could motivate banks to hold even more capital, and could provide incentives for moving towards longer-term and more stable funding.

Over the long term, CBDCs could also bring about stabilizing structural changes to the financial system. As noted above, advanced countries have already experienced a considerable trend towards more credit intermediation by non-banks. If the introduction of CBDCs sets in motion a further decoupling of the process of credit intermediation from the payment system and the process of money creation, financial fragility might be reduced substantially. By prompting a move away from fractional-reserve banking towards (1) specialized payment service providers that would function as narrow banks offering digital wallets that are fully backed by central bank money (in this case CBDCs); and (2) non-bank intermediaries financed by longer-term funding, the connection between lending and the payment system would be severed. As a result, leveraged banks that provide risky lending would no longer be at the center of the payment system, and the financial system would get a more robust structure. Thus, introducing CBDCs could—although on first sight paradoxical—be a step towards making the financial system safer and more stable.

V. What are the key design considerations for CBDCs?

The introduction of retail CBDCs would mark the next stage in the evolution of cash. While the precise form could change, CBDC would be a central bank liability transferable by digital means. The primary design considerations for retail CBDCs relate to the architecture, policy checks and balances, and operational requirements. From the central bank point of view, the optimal design calls for a CBDC that would minimize possible negative consequences for the financial system, be operationally easy, inexpensive and secure, and meet user needs.

From the individual user point of view, the CBDC instrument must be attractive enough so that people would actually transact through them. The last thing that central banks would want is to introduce an instrument that is not broadly used. As such, tradeoffs and features in CBDC design have to be carefully considered. For example, one important tradeoff arises in the case of anonymity/privacy, as users tend to desire a cash-like anonymous instrument, whereas central banks may seek full *visibility,* if permissible by privacy laws.

Accordingly, the first design characteristic is the architecture of retail CBDCs, with two models primarily under consideration.[20] The first is the *direct* model, where the CBDC is operated by the

[20] Auer and Böhme (2020) and Auer et. al. (2020b) provides a detailed discussion of different architectural models.

central bank, which keeps a record of balances and handles all payment services, including transactions and storage. Users have accounts with the central bank. The second is a *hybrid* model, which is a two-tier structure, where the central bank issues CBDC as a digital bearer instrument, distributed through commercial banks and non-bank payment service providers, for use by individuals and small businesses.[21] Storage and processing are decentralized in a payments instrument operated by PSPs.

While the *direct* model is a possibility, it may not be a practical option for most central banks because of a number of reasons.[22] First, building and operating the payment network would be a huge challenge for a central bank and would be costly. Second, it could be cut-off from future private sector innovations. Third, central banks may not be able to legally offer accounts for retail use, while there is the practicality of potentially having to deal with hundreds of millions of customers, depending on the size of the country. Fourth, the central bank would know the identity of customers, which means that privacy for retail users would not be assured. Fifth, potential policy concerns related to banking disintermediation and financial stability could be exacerbated in a system where the central bank offers accounts to consumers.

By contrast, the *hybrid* model would not have these shortcomings. The central bank would provide the core platform with necessary functionality for retail CBDC, including issuance, monitoring and control, and withdrawal from circulation. The PSPs would connect to the core platform to provide customer-facing services. The two-tier retail CBDC would be a classic public-private partnership, between the central bank as the issuer and provider of the CBDC instrument, and banks and non-bank PSPs as distributors. The central bank would in effect leverage off the innovations of the private sector, resulting in cost-savings and efficiency gains. It would also be important that cash and the retail CBDC operate side-by-side, so that no one is financially excluded for want of digital access.

Turning to policy checks and balances, these should aim to mitigate concerns of unintended credit disintermediation and/or bank runs, should they arise, while enhancing the financial integrity of the system by guarding against use for illicit purposes. Table 1 sets out the key policy requirements as well as the operational ones. Ideally, the CBDC should be non-interest bearing. Positive interest rates could bring competition with bank deposits while negative interest rates by taxing the public would limit its use. However, the architecture should

[21] Some have proposed a third approach, an indirect or synthetic CBDC model (see Adrian and Mancini-Griffoli 2019 and Auer et. al. 2020b). This would take the form of a payment system operated by the private sector (PSPs and/or stablecoins). Consumers would have claims on the private entities, which would back them up with funds at the central bank. However, central banks are typically not considering this model because it is not a true CBDC (Bank of England 2020). Moreover, it would not provide all of the benefits associated with CBDCs, and pre-supposes strict and effective regulation and supervision to ensure that all liabilities were fully backed 24/7 with central bank funds.

[22] Several are highlighted by Brainard (2019 and 2020) from the perspective of the Federal Reserve Board.

eventually allow for both, positive and negative interest rates. Bindseil (2020) has proposed a two-tiered remuneration structure to address concerns of potential bank disintermediation and systemic runs in crisis situations. Central banks considering CBDCs could also put in place limits on transactions and total holdings in e-wallets as precautionary features.

The retail CBDC should be designed in such a way that the anonymity features of cash are largely preserved so that users would want to use the instrument, while ensuring that it is not used for illicit purposes. A solution might be for the central bank to have a dashboard that could display all the transactions, but with anonymity ensured up to a certain threshold amount set by regulators. High-value transactions beyond the threshold would not be anonymous. As financial integrity is important for central banks, the CBDC could be designed so that payment service providers have the obligation to ensure that anti-money laundering (AML), know-your-customer (KYC) and combating the financing of terrorism (CFT) requirements are met.

The third design consideration is operational requirements for retail CBDCs. Drawing on discussions with a number of advanced and developing country central banks, the key requirements are: hardware- and software-based security protection against counterfeiting and cyberattack; universal accessibility, 24/7, with offline transaction capability; scalability as demonstrated by the ability to handle large volume of retail transactions fast and efficiently; ensure final and not probabilistic settlement of transactions; interoperability or the ability to transact seamlessly with different payment rails or systems; traceability or the central bank being able to monitor transactions but without the identity of users being revealed, so as to be in compliance with privacy laws; and energy efficiency.

Another desirable feature for some central banks is that retail CBDC should be programable. This can be construed to mean that central bank can program the core system to take into account policy objectives, while PSPs can make changes in customer-facing parts.[23] Retail CBDCs should also be able to be linked with wholesale transaction networks, which would continue to be conducted on state-operated RTGS systems, and can potentially be used for cross-border transactions to spur efficiency gains.

In sum, the *hybrid* model should be the preferred approach for retail CBDCs. Chart 4 illustrates an example of a hierarchical *hybrid* architecture developed by eCurrency, with the central bank issuing retail CBDC as bearer objects and distributing them through PSPs for use by individuals and small businesses through all existing payment rails, while meeting policy and operational requirements (Das Gupta and Dharmapalan, 2020). With technology constantly changing, the central bank can then continue to benefit from private sector innovations in payment systems while AML/CFT/KYC is taken care off by PSPs. Central banks typically do not want to have to take on the burden of financial integrity compliance themselves. Nor do they want to take on other customer-facing tasks, for which the private sector is better equipped.

[23] See Bank of England (2020) for a discussion of programmable considerations for CBDCs.

Tables 2 and 3 illustrate examples of policy and operational requirements suggested by the Bank of Canada (Engert and Fung, 2017) and the South African Reserve Bank (Expression of Interest for Electronic Digital Ledger, 2019). Both are comprehensive, detail key attributes, and are in line with the broad design principles suggested above. Currently, two retail CBDC projects by major central banks are underway (e-yuan pilot by the People's Bank of China and e-krona proof-of-concept by Riksbank).[24] Another two are imminent (South African Reserve Bank feasibility project and Bank of Jamaica pilot). They follow the *hybrid* approach incorporating key policy and operational requirements, although it is possible that the South African and Jamaican projects may experiment with both architectures.[25]

VI. How should central banks decide which technology to use?

It is probably best to choose specific technologies after the central bank has decided on the desirable design attributes of the CBDC system, and after extensive internal consultations amongst the policy, supervision, payment and IT groups. In particular, the chosen technology has to be able to meet the scale needs of CBDCs, be able to deliver finality of settlement, and be fully secure, amongst the other policy and operational requirements.[26]

On this score, Table 4 compares the eCurrency Digital Secure Currency (DSC) technology with blockchain. After extensive research and discussions with more than 30 central banks, eCurrency developed the DSC technology specifically to meet central bank requirements. The eCurrency solution allows the issuance, distribution, and transaction of CBDCs with sufficient speed, scale, instant and final settlement, and continuous operations (24/7). Competing technologies, such as blockchain, have yet to demonstrate the same attributes required of a retail CBDC. Moreover, blockchain uses excessive energy and computing power.

eCurrency DSC technology infuses trust by converting the electronic values transacted in PSPs into sovereign-backed currency issued by the central bank. It does not change how consumers interact with the existing payment methods they use (payment cards, mobile money accounts, etc.). By delinking the CBDC digital instrument from the identity of who is holding them in accounts with PSPs, central banks can observe usage and collect data through a dashboard,

[24] See Auer et. al. (2020b), Fan (2020), Group of Thirty (2020), and Yao (2018).

[25] It should be noted that while many central banks are researching retail CBDCs, only six projects are currently active. In addition to the four mentioned above, pilots appear to be underway in the Bahamas and the Eastern Caribbean. See Kiff et. al. (2020) for a comprehensive list of countries where central banks are exploring retail CBDC.

[26] See Shah et al. (2020) and Auer and Böhme (2020) for discussion on technology considerations for retail CBDCs, which are broadly in line with the design attributes we set out. A point to note is that there is increasing realization that distributed ledger technology (DLT)/blockchain is not able to offer the scale, speed, settlement finality and continuous operation needed for a retail CBDC. Retail CBDC requirements are very different from what is needed for wholesale CBDCs, where it is possible to use DLT. Regardless, the decentralization inherent in DLT is the very anti-thesis of central bank control over currency.

while anonymity is preserved for small transactions. The anonymity threshold is set by each central bank in accordance with the privacy law.

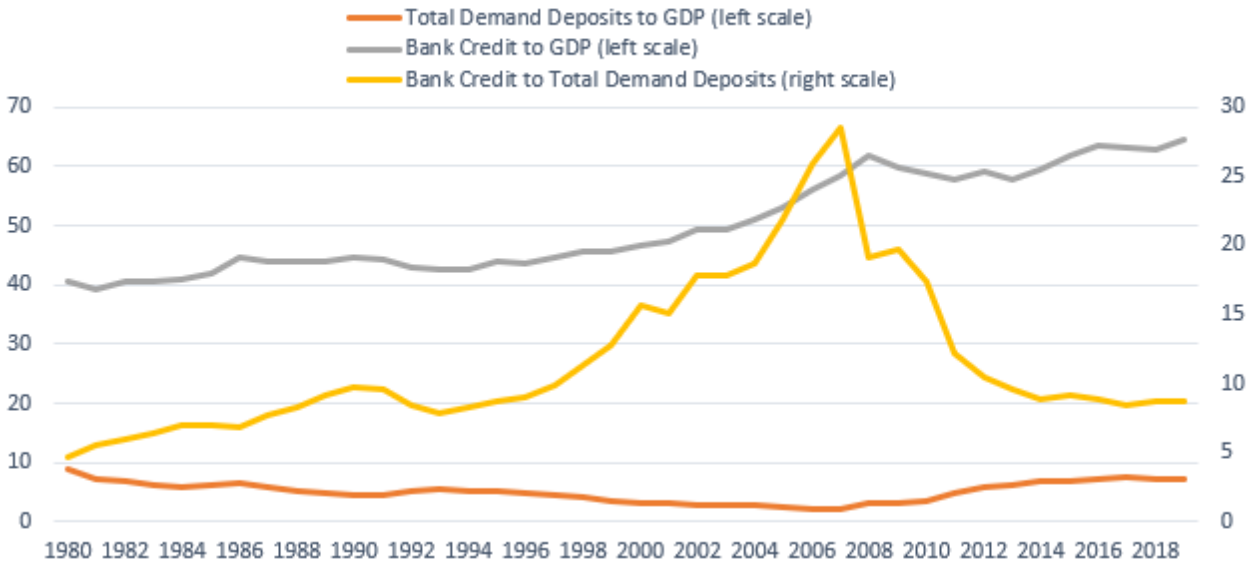
VII. Conclusions

We reach three broad conclusions for a retail CBDC designed for the digital age. With regard to drivers, it appears that central banks are considering CBDCs because they want to help maximize economic gains and remain relevant in a digital world, while safeguarding financial stability. A key problem for central bankers is how to continue to provide a service—a trusted, safe, and efficient means of payment—that works for all in a digitalized society by including both cash and state-issued digital tender such as CBDCs. As to the question of whether retail CBDCs could be potentially destabilizing, we have argued that possibly adverse effects on credit intermediation and lending rates should not be overstated, and that concerns of CBDCs facilitating the possibility of bank runs are largely unfounded. Paradoxically, introducing retail CBDCs could be a step towards more fundamental structural changes in the banking system, such as separating lending from payment systems, which could make the financial system safer and more stable.

Nevertheless, design considerations have to be made carefully if central bank policy objectives are to be met and risks mitigated. In this regard, it is likely that a non-interest-bearing retail CBDC *hybrid* architecture designed as a public-private partnership with transaction and holding limits and meeting operational requirements is the way forward. This would also allow central banks to benefit from technology and other innovations developed by private sector payment providers while maintaining control over issuance, distribution, regulation and supervision, along with the ability to monitor transactions.

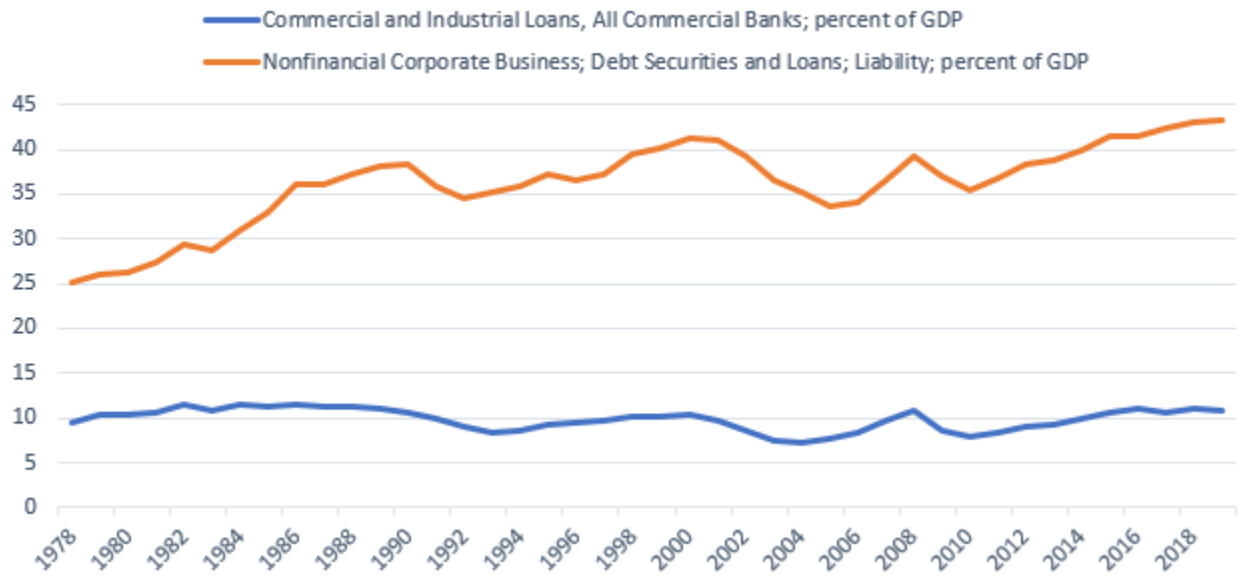
ANNEX: Charts and Tables

Chart 1: United States - Bank Deposits and Bank Lending



Source: Federal Reserve of St. Louis

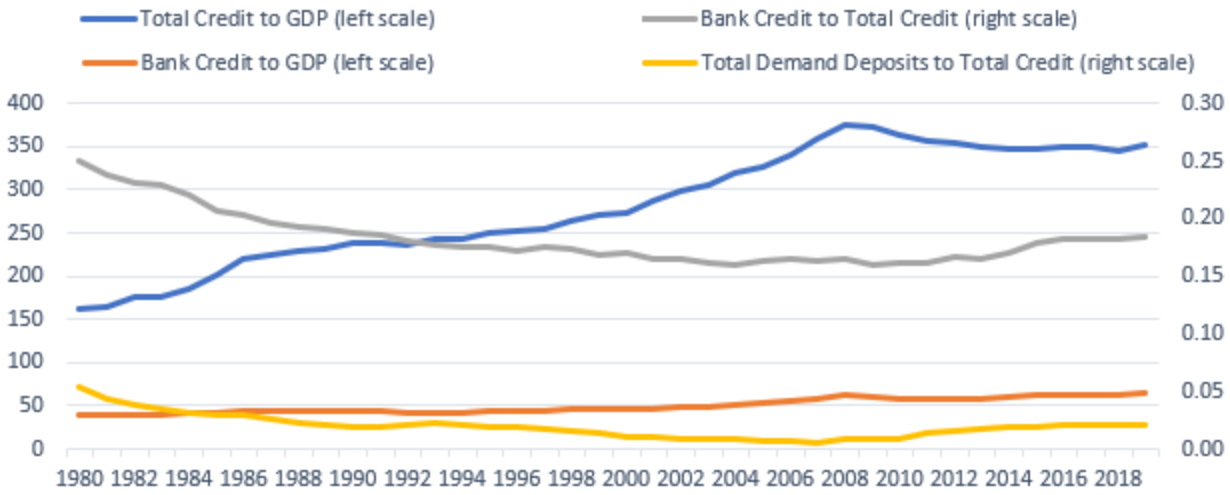
Chart 2: United States - Lending to Non-Financial Sector



Source: Federal Reserve of St. Louis

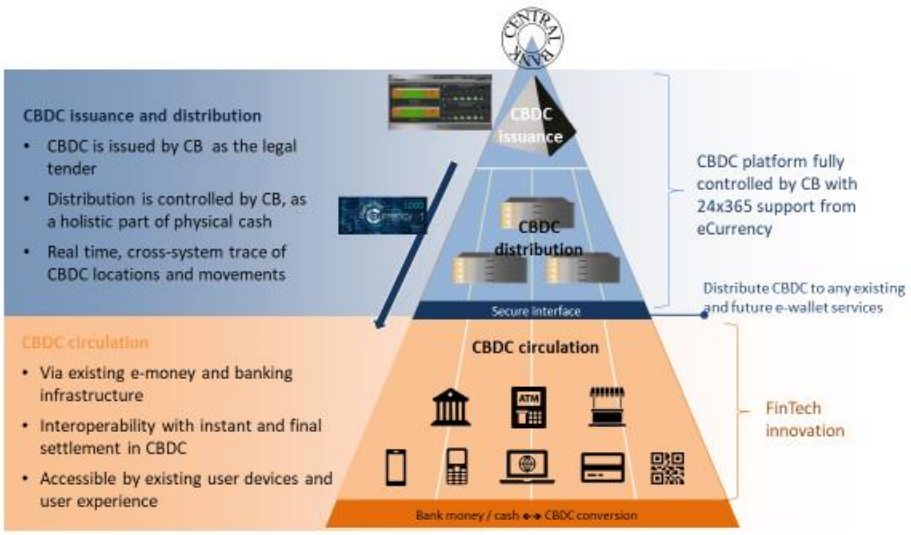
* Excluding mortgages

Chart 3: United States - The Relative Decline in Bank Intermediation



Source: Federal Reserve of St. Louis

Chart 4: Retail CBDC Architecture



Source: eCurrency

Table 1: CBDC Policy and Operational Requirements

Legal tender and policy	CBDC is issued and controlled by the central bank. It is a liability on its books. Its supply must be set by policy.
	CBDC complements physical cash, operates in parallel with it, must complement the existing payment mechanisms.
	CBDC must not destabilize the financial sector. Financial integrity must be preserved while allowing for privacy. It must implement policy decisions regarding its supply and movement.
	Last-mile considerations require CBDC to be transmittable over existing payment and wallet systems without requiring complete replacement of existing systems and networks.
Security	The CBDC security must be based on hardware and software certified to the highest available standards.
	The CBDC must be secured against counterfeiting and any attempts at counterfeiting must render the CBDC units invalid.
	CBDC features and its security must be remotely upgradable in order to keep pace with improvements in technology and security mechanism.
Accessibility	The CBDC must be all inclusive, available to anyone with access to related technology and must transact without the need for a bank account.
	Consumers and businesses must be provided with easily accessible channels to obtain or return CBDC in exchange for physical cash or commercial bank money.
	CBDC must be able to operate on a peer-to-peer (face-to-face) basis in the absence of connectivity (off-line), as well as over online channels.
	CBDC must be cheaper to operate than physical cash to ensure acceptance.
Traceability	Auditability of transactions must be parameterised in order to determine the balance between anonymity of the transacting parties and traceability of fund transfers.
	The central bank, must be able to monitor its distribution and usage, and the degree of monitoring must comply with the privacy laws of the central bank's jurisdiction and evolve with the law.
	The CBDC monitoring as allowed by law must be in real-time to give the central bank additional policy tools impossible to attain with physical cash.
IT characteristics	The CBDC solution must be able to handle large, country and region-wide volume of transactions fast and efficiently.
	CBDC must be at least as reliable as existing financial systems and must be "always on" – in real time 24x7.
	CBDC should expend minimal energy resources and consume only negligible power.
	The CBDC solution must easily integrate with other existing financial systems via open, standardised interfaces.

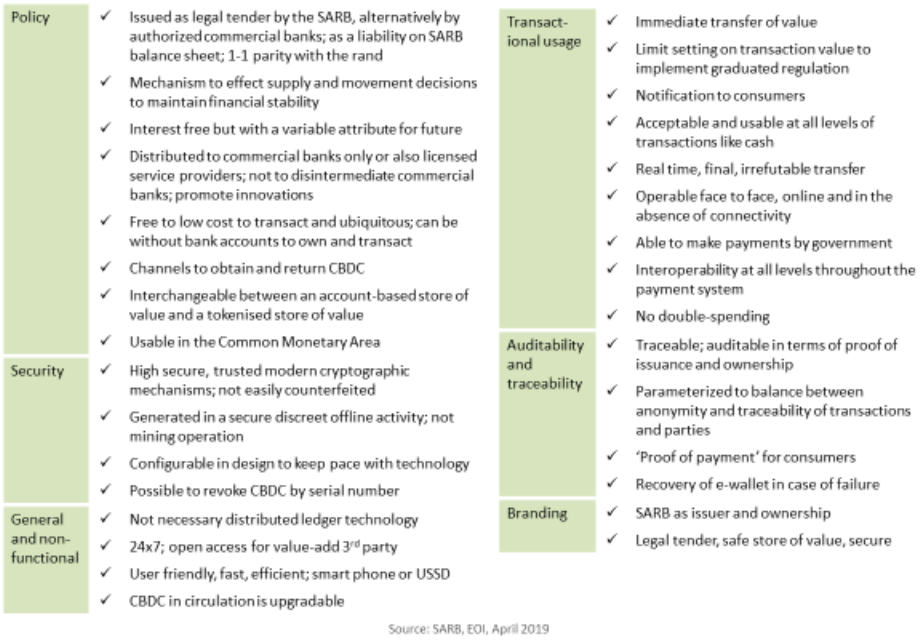
Source: Adapted from various central bank requirements and eCurrency

Table 2: Potential CBDC Design Approach I, Bank of Canada

Fiat currency	✓ Denomination in sovereign currency ✓ Legal tender status like cash ✓ Convertibility to reserves, bank notes at par	Supply	✓ Set by the central bank ✓ Demand-determined and perfectly elastic
Interest and fee	✓ Non interest bearing ✓ Central bank fees not charged; commercial bank fee optional	Distribution	✓ Available for purchase and withdrawal at regulated financial institutions ✓ Regulated financial institutions with accounts at the central bank or through clearing banks ✓ KYC, AML, CFT compliance by banks prior to anonymous transactions ✓ No direct access to the central bank for households and firms to obtain, store or return CBDC
Access	✓ Non-exclusive access for anyone with access to related technology ✓ Chip card or digital wallet through various devices with online capability ✓ Digital wallet by private providers certified by the central bank ✓ Underlying technology (e.g. digital ledger) not specified	Finality and irrevoca-bility	✓ Transactions confirmed nearly instantaneously, settled irrevocably quickly ✓ Timing of finality and irrevocability dependent on underpinning technological solution
Availability	✓ Available 24/7 like cash and other electronic payments		
Confiden-tiality	✓ Anonymous or pseudonymous; not traceable ✓ Non-reversible, unless through reversing transactions by both transacting parties		

Source: Bank of Canada Staff Discussion Paper 2017-16 "Central Bank Digital Currency: Motivations and Implications"

Table 3: Potential CBDC Design Approach II, South African Reserve Bank



Policy	✓ Issued as legal tender by the SARB, alternatively by authorized commercial banks; as a liability on SARB balance sheet; 1-1 parity with the rand ✓ Mechanism to effect supply and movement decisions to maintain financial stability ✓ Interest free but with a variable attribute for future ✓ Distributed to commercial banks only or also licensed service providers; not to disintermediate commercial banks; promote innovations ✓ Free to low cost to transact and ubiquitous; can be without bank accounts to own and transact ✓ Channels to obtain and return CBDC ✓ Interchangeable between an account-based store of value and a tokenised store of value ✓ Usable in the Common Monetary Area
Security	✓ High secure, trusted modern cryptographic mechanisms; not easily counterfeited ✓ Generated in a secure discreet offline activity; not mining operation ✓ Configurable in design to keep pace with technology ✓ Possible to revoke CBDC by serial number
General and non-functional	✓ Not necessary distributed ledger technology ✓ 24x7; open access for value-add 3rd party ✓ User friendly, fast, efficient; smart phone or USSD ✓ CBDC in circulation is upgradable
Transact-ional usage	✓ Immediate transfer of value ✓ Limit setting on transaction value to implement graduated regulation ✓ Notification to consumers ✓ Acceptable and usable at all levels of transactions like cash ✓ Real time, final, irrefutable transfer ✓ Operable face to face, online and in the absence of connectivity ✓ Able to make payments by government ✓ Interoperability at all levels throughout the payment system ✓ No double-spending
Auditability and traceability	✓ Traceable; auditable in terms of proof of issuance and ownership ✓ Parameterized to balance between anonymity and traceability of transactions and parties ✓ 'Proof of payment' for consumers ✓ Recovery of e-wallet in case of failure
Branding	✓ SARB as issuer and ownership ✓ Legal tender, safe store of value, secure

Source: SARB, EOI, April 2019

Table 4: Comparing the eCurrency DSC and Blockchain Technologies

	eCurrency	Blockchain
Nature	Bearer instrument	Ledger entries
Anonymity	As allowed by law	Private key identifies owner
Settlement	Instant, final	Probabilistic convergence
Deployment impact	Uses existing payment rails	Replaces existing systems
Scalability	Scalable to '000s transactions per second	Struggling to reach retail levels
Efficiency	Standard computing energy requirements	Exorbitant processing power requirements
Double-spending	Completely solved	Vulnerable to majority (>50%) attacks
Offline use	Possible with secure devices and NFC	Requires constant network connection
Consensus	P2P without additional requirements	Requires consensus, notary, or similar mechanism

Source: eCurrency

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